# Feasibility Study For Bainbridge Naval Training Center, Port Deposit, Maryland

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# Acronyms

| | |
|---|---|
| ABS | absorption factor |
| AMSL | above mean sea level |
| ARAR | applicable or relevant and appropriate requirements |
| ASC | Analytical Services Center |
| AT | averaging time |
| ATSDR | Agency for Toxic Substances Disease Registry |
| AWQC | Ambient Water Quality Criteria |
| BGS | below ground surface |
| BH | borehole |
| BNA | base/neutral and acid extractable organic compounds |
| BTAG | Biological Technical Assistance Group |
| BTEX | benzene, toluene, ethylbenzene, and xylene |
| BW | background well or body weight |
| CB | cholorbenzene |
| CDI | chronic daily intake |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund) |
| CLP | Contract Laboratory Program |
| CNS | central nervous system |
| COC | chemical of concern |
| COPC | chemical of potential concern |
| COPEC | chemical of potential ecological concern |
| CRQL | contract-required quantitation limit |
| CWA | Clean Water Act |
| DCB | dichlorobenzene |
| DCE | dichloroethylene |
| DDD | dichlorodiphenyldichloroethane |
| DDE | dichlorodiphenyldichloroethylene |
| DDT | dichlorodiphenyltrichloroethane |
| DERA | Desktop Ecological Risk Assessment |
| DERP | Defense Environmental Restoration Program |
| DI | deionized |
| DOT | Department of Transportation |
| E&E | Ecology and Environment, Inc. |
| EBS | Ecological Baseline Survey |
| ECAO | Environmental Criteria and Assessment Office |
| ED | exposure duration |
| EEQ | environmental effects quotient |
| EF | exposure frequency |
| EFA | Engineering Facilities Activity |

| | |
|---|---|
| EPA | United States Environmental Protection Agency |
| ERA | Ecological Risk Assessment |
| FC | fraction of contacted sediment |
| FDA | Food and Drug Administration |
| FI | fraction ingested |
| FOD | frequency of detection |
| FS | Feasibility Study |
| FTA | Fire Training Area |
| GC/MS | gas chromatography/mass spectrometer |
| GI | gastrointestinal |
| gpd | gallons per day |
| gpm | gallons per minute |
| GRA | General Response Actions |
| GW | ground water |
| HA | Health Advisories |
| HDPE | high density polyethylene |
| HEAST | Health Effects Assessment Summary Tables |
| HHRA | Human Health Risk Assessment |
| HI | hazard index |
| HQ | hazard quotient |
| HSA | hollow stem auger |
| HSWA | Hazardous and Solid Waste Amendment |
| IARC | International Agency for Research on Cancer |
| ID | inside diameter |
| IEUBK | Integrated Exposure Uptake Biokinetic |
| IR | ingestion rate |
| IRA | Interim Remedial Action |
| IRIS | Integrated Risk Information System |
| IRM | Interim Remedial Measure |
| IRP | Installation Restoration Program |
| K | conductivity |
| kg | kilogram |
| LADI | lifetime average daily intakes |
| LDR | land disposal restrictions |
| LOAEL | lowest-observed-adverse-effect level |
| $m^3$/day | cubic meters per day |
| MCL | Maximum Contaminant Levels |
| MCLG | Maximum Contaminant Level Goals |
| MDE | Maryland Department of the Environment |
| MDL | Method Detection Limit |
| MDNR | Maryland Department of Natural Resources |
| MF | modifying factor |
| mg/kg | milligrams per kilogram |
| mg/kg-day | milligrams per kilogram per day |
| MS/MSD | Matrix Spike/Matrix Spike Duplicate |
| NAS | National Academy of Science |
| NAVFACENGCOM | Naval Facilities Engineering Command |
| NCP | National Contingency Plan |

| | |
|---|---|
| NEESA | Naval Energy and Environmental Support Activity |
| NOAEL | no-observed-adverse-effect level |
| NPDES | National Pollution Discharge Elimination System |
| NPL | National Priorities List |
| NPT | Navy Provided Text |
| NRHP | National Register of Historic Places |
| NTC | Naval Training Center |
| NTCR | non-time critical removal |
| O&M | Operation and Maintenance |
| OD | outside diameter |
| OHM | OHM Remediation Services Corporation |
| OSHA | Occupational Safety and Health Administration |
| OSWER | Office of Solid Waste and Emergency Response |
| PAH | polynuclear aromatic hydrocarbon |
| PCB | polychlorinated byphenyl |
| PCE | tretrachloroethane |
| POTW | Publicly Owned Treatment Works |
| ppb | parts per billion |
| ppm | parts per million |
| PRG | preliminary remediation goals |
| psi | pounds per square inch |
| PVC | polyvinyl chloride |
| QA/QC | quality assurance/quality control |
| QAPP | Quality Assurance Project Plan |
| RAGS | Risk Assessment Guidance for Superfund |
| RAO | Remedial Action Objectives |
| RAS | Routine Analytical Services |
| RBC | risk-based concentration |
| RBSC | risk-based screening concentration |
| RCRA | Resource Conservation and Recovery Act |
| RfC | reference concentration |
| RfD | reference dose |
| RI | Remedial Investigation |
| RI/FS | Remedial Investigation/Feasibility Study |
| RME | reasonable maximum exposure |
| RNP | reference not provided |
| RO | Reverse Osmosis |
| ROD | Record of Decision |
| SA | surface area |
| SAS | Special Analytical Services |
| SD | Sediment Sample |
| SDWA | Safe Drinking Water Act |
| SETAC | Society of Environmental Toxicology and Chemistry |
| SF | slope factor |
| SI | Site Inspection |
| SLERA | Screening Level Ecological Risk Assessment |
| SPDES | State National Pollution Discharge Elimination System |
| S/S | Solidificaiton/Stabilization |

| | |
|---|---|
| SSL | Soil Screening Level |
| SVOC | semi-volatiles organic compound |
| SW | surface water |
| SWL | static water level |
| T | transmissivity |
| TAL | Target Analyte List |
| TBC | to be considered |
| TCE | trichloroethylene |
| TCL | Target Compound List |
| TCLP | toxicity characteristic leaching procedure |
| TPH | total petroleum hydrocarbons |
| TSD | Transfer, storage, and/or disposal |
| $\mu$g/kg | micrograms per kilogram |
| $\mu$g/L | micrograms per liter |
| UCL | upper confidence limit |
| UF | ultrafiltration or uncertainty factors |
| USCOE | United States Army Corp of Engineers |
| USDA | United States Department of Agriculture |
| USEPA | United States Environmental Protection Agency |
| USFWS | United States Fish and Wildlife Service |
| USGS | United States Geological Survey |
| UV | Ultraviolet |
| UST | Underground Storage Tank |
| VC | vinyl chloride |
| VLF | very low frequency |
| VOC | volatile organic compound |
| WQC | Water Quality Criteria |

*See original RI for sampling notation.

# Executive Summary

The former Navy Training Center - Bainbridge (NTC), located in Port Deposit, Maryland, was an active Navy installation from 1941 to 1949, 1951 to 1957, and 1962 to 1976. After final closure, the Navy identified two likely areas of environmental concern; Site 1, the Old Landfill, and Site 2, the oil separator pit at the Fire Training Area (FTA).

Ecology and Environment, Inc. (E & E) was contracted by the Navy to perform a Remedial Investigation/Feasibility Study (RI/FS). E & E carried out the first phase of the RI in 1990 and 1991. Based on the results of this investigation, it became apparent that the full nature and extent of contamination had not been identified. The Navy directed E & E to perform Supplemental Investigations (SI) as a second phase to the RI. These SIs were conducted during 1993 and 1994. This Feasibility Study (FS) report presents:

- assessments and conclusions concerning human health and ecological risks;
- Preliminary Remediation Goals (PRGs) based on these risks, and;
- applicable remedial alternatives.

This FS is based upon analyses of available data and considers the potential beneficial impacts from the implemented IRMs. The FS is intended to inform decision makers of the need for, and approach to, remedial actions.

Based on the 1991/1994 sampling data and excluding areas remediated by previous IRMs, E & E concluded the groundwater contaminants of concern (COCs) at the Old Landfill site (Site 1) consisted of metals (antimony, iron and manganese) and VOCs (chlorobenzene, chloroform, TCE and VC). The sediment COCs consist of nine metals and 13 PAHs. The groundwater COCs at the Fire Training Area (Site 2) consisted of metals (iron and manganese), 1,1,2,2-PCA, chloroform, and six PAHs. The sediment COCs for Site 2 consisted of four metals, cadmium, chromium, lead, and manganese. Because sediments contaminated by metals at the Fire Training Area are isolated to one location and contaminant concentrations were only slightly above preliminary cleanup goals, remediation of the sediments was not deemed appropriate. Surface water contamination was dealt with indirectly because it is impractical to directly remediate surface water bodies, and the completed IRMs have likely reduced impacts to surface water.

For both sites, remedial action alternatives were developed and screened to three alternatives for detailed analysis. These three alternatives, for both sites, included:

- No Action;
- Institutional Controls; and
- Remediation/Treatment.

The three alternatives were evaluated based on seven criteria developed by the United States Environmental Protection Agency (USEPA):

- Overall protection of human health and the environment;
- Compliance with applicable or relevant and appropriate recommendations;
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility or volume;
- Short-term effectiveness;
- Implementability; and
- Cost.

The three alternatives developed for each site were compared with each of the seven criteria. Based on this comparison, a recommended alternative was selected for each site.

The remedial action recommended by E & E for both Sites 1 and 2 was Institutional Controls. This decision was based on the following considerations:

- Considerable uncertainty associated with the Desktop Ecological Risk Assessment, which drives the preliminary sediment cleanup goals;
- The chemical data is up to eight years old, and recent, pre-ROD

sampling (April 1999) indicates downward trends of contamination in all media of concern;

- Contaminant sources and migration pathways have been removed/reduced through IRMs, resulting in reduced contaminant concentrations in sediment and groundwater; and
- Possibility that benthic and aquatic life and habitat would be destroyed through sediment removal at Site 1.

The Institutional Control alternative involves reducing human exposure to the contaminants by restricting exposure at the sites. Institutional Controls would be accomplished through deed restrictions on intrusive activities at the landfill and new well construc tion at both sites. An environmental monitoring program would also be performed semi-annually for two years. The monitoring program would record current site conditions including contami nant migration and concentration changes. This data would be used to evaluate the effect current concentrations of COCs may have on potential site receptors and to determine if additional actions are warranted.

The estimated total present-worth costs of the recommended alternatives are $55,000 at Site 1 and $30,000 at Site 2.

# 1 Introduction

Under Naval Facilities Engineering command (NAVFACENGCOM) Chesapeake Division Control No. N62477-90-C-0183, the United States Department of Navy directed Ecology and Environment, Inc., (E & E) to perform a Remedial Investigation/Feasibility Study (RI/FS) at the Naval Training Center (NTC) in Port Deposit, Maryland (see Figure 1-1). The work was performed in the context of the Installation Restoration Program (IRP) initiated by the Department of Navy as part of the Defense Environmental Restoration Program (DERP) to evaluate suspected problems associated with past waste disposal and spill sites at Department of Defense installations.

The NTC at Port Deposit, Maryland, was active as a Navy installation from 1941 to 1949, 1951 to 1957, and 1962 to 1976. Subsequently, part of the NTC was used as a Job Corps Center, operated by the Department of Labor between 1978 and 1990. Through the IRP, the Navy identified two likely areas of environmental concern. These were the main locations at which hazardous materials or regulated substances historically had been used or deposited at the NTC, and at which adverse environmental impact could not be ruled out. Site 1 is the Old Landfill, at which pesticides had been recommended for disposal in a 1968 Atlantic Division Naval Facilities Engineering Command report; and Site 2, active since 1944, is the oil separator pit at the Fire Training Area (FTA) (Versar 1988).

Versar, Inc., was contracted by the Navy in 1987 to perform a hydrogeological investigation of both areas, and to prepare a Hazard Ranking System Score for the facility as a whole. The field activities were carried out in 1988, and the final report. *Hydrogeological Investigation of Waste Sites* at *the Former Naval Training Center,* was delivered in 1989 (Versar 1989). On May 23, 1990, a site survey was performed by the Naval Energy and Environmental Support Activity (NEESA) which included a review of records and interviews with site personnel. This resulted in the release of the Preliminary Assessment Report (NEESA 1991). The recommendations of this report were that an RI/FS be carried out for Sites 1 and 2 at the NTC to identify and propose appropriate remedial measures.

## 1.1 Project Approach

The first phase of the RI was carried out by E & E in 1990 and 1991. From the results of this effort, it became apparent that the full extent of contamination had not been delineated for either site and specifically that insufficient information was available as to the potential for off-site migration of contaminants in the groundwater. The Maryland Department of the Environment (MDE), in a letter of September 15, 1992 (MDE 1992), requested that additional effort be undertaken to fill data gaps in the RI, prior to it being accepted as final. The Navy tasked E & E to perform supplemental investigations under the existing contract, and field work for this second phase RI was conducted between 1993 and 1994. The final RI was issued in February, 1999.

This report addresses all components of the FS process. This section sets the framework upon which the FS is performed. General Remedial Action Objectives (RAOs) are developed for the two sites and medium-specific preliminary remediation goals are established. This information is then used to identify the areas of each site that are addressed in subsequent components of the FS. The development of RAOs is presented in Section 2. The identification and screening of appropriate remedial technologies is presented in Section 3, and the preliminary alternative development and screening is presented in Section 4. A detailed analysis/evaluation of alternatives is presented in Section 5. Section 6 includes a summary and recommendations.

## 1.2 Regional and Facility Background

### 1.2.1 Regional History

The town of Port Deposit got its name from shipping and trans-shipment activities that took place there in the mid to late 1800s. Port Deposit served as a junction for commerce up and down the Susquehanna River, and at a place where cargo was stored temporarily, before being transferred, primarily from upstream to ocean-going vessels. Virtually all timber cut in the watershed of the Susquehanna River was brought here before further shipment down the Chesapeake Bay. Thousands of "arks," or large, flat wooden boats, would float down the Susquehanna to deliver timber, coal, flour, and whiskey to Port Deposit. The larger commercial ships sailing up from the Chesapeake Bay would load up here, and then deliver their cargo to the larger ports in Baltimore, Washington, and elsewhere.

By 1860, the town had grown to approximately 2,000 people, with a large number of transient residents, and over 70 industries and businesses. As the logging industry diminished and trains replaced river ship as the preferred shipping alternative, Port Deposit began to change and to resemble its current profile. The town is 1 1/4 miles long and less than 400 feet wide. Route 222, which is the main street, runs the length of town and parallels the river. There is a single row of approximately 100 houses to the east of Route 222. A 100- to 200-foot bluff to the north and the Susquehanna River to the south have prevented development in either direction and have served to create the elongated town layout. According to the 1990 census, the population of Port Deposit is currently 685 (Rand McNally Road Map 1995).

Perryville, located 5 miles southeast of the NTC, had 2,456 residents in 1990, and is the nearest town to Port Deposit with a population greater than 1,000 (Rand McNally Road Map 1995).

### 1.2.2 Facility Description

The NTC occupies 1,200 acres on the north bank of the Susquehanna River near the town of Port Deposit in Cecil County, Maryland (see Figure 1-1). It is located approximately 5 miles upstream of the confluence of the Susquehanna River with the Chesapeake Bay, and 37 miles northeast of the city of Baltimore at 39°36'45" N latitude and 76°51'18" W longitude. A steep 100- to 200-foot bluff marks the southern boundary of the NTC and the northern extent of the town of Port Deposit. State Routes 276 and 222 border the NTC to the west and southwest, respectively. The NTC is bordered by rural, residential, and wooded areas to the north and east.

Extensive demolition of base buildings has occurred during the past five years. The buildings were razed to their foundations and the debris was transported to a new rubble landfill at the facility for disposal. Each building site was subsequently graded and seeded with grass. Approximately 40 buildings had been previously demolished in the late 1970s, and the debris was buried in the northern part of the Old Landfill.

Presently, several buildings remain at or near the parade ground and one building is used for offices at the NTC. The historic buildings in the Tome School for Boys in the southwestern portion of the NTC remain, and are on the National Register of Historic Places (NRHP 1991).

### 1.2.3 Facility History

The NTC was built in 1942 on 1,230 acres of land. A 330-acre property whose land and buildings were formerly home to the Tome School for Boys, and 900 acres of adjoining property were acquired for the NTC. It was used immediately to house a series of training camps for the U.S. Navy that provided training for more than 260,000 men and women between 1942 and 1947. At its peak, in 1945, the base housed more than 38,000 people.

After the end of World War II, the Navy slowly closed all activities at the base and by 1948, the base was reduced to caretaker status. However, 2 years later, with the start of the Korean War, the NTC was returned to active status. The base continued to train sailors at a steady pace until 1957. At that point, the Navy, facing a shortage of funds, moved several activities to other bases and reduced the base population from 14,500 to 4,500.

In 1961, the Navy decided to expand the NTC by establishing the Nuclear Power School and the Naval Reserve Manpower Center on base. Within 10 years, the NTC had grown to be one of the largest training facilities in the county. It employed over 5,500 military and civilian employees with a yearly payroll of $5.8 million in 1971. However, in 1972 the Navy began scaling back operations, and the NTC closed on June 30, 1976.

In 1978, the U.S. Department of Labor, Employment and Training Administration, leased 264 acres from the U.S. Navy for use as part of the Job Corps program. The Chesapeake Job Corps Center was a contract-operated facility for training of disadvantaged youth. During operations, the center housed approximately 200 staff members and 300 students. The Chesapeake Job Corps ceased operation in August 1990.

Part of the NTC, still known as the Tome School, includes buildings on the National Register of Historic Places. In addition, the NTC also contains an area of archaeological significance, the Snow Hill Free-Black community site, which meets the criteria for inclusion on the National Historic Register.

Currently, the Chief of Naval Technical Training Detachment maintains a small Base Closure Force at the NTC for administrative and maintenance purposes.

### 1.2.4 Previous Investigations

In 1987, Atlantic Division, NAVFACENGCOM identified the Old Landfill (Site 1), a solid waste landfill operated from 1942 until base closure, and the Fire Training facility (Site 2), including an oil separator pit (see Figure 1-1), as areas where potential surface or subsurface contamination may have resulted from NTC operations and disposal practices (undocumented). In 1988, as part of the Navy's IRP, a hydrogeologic investigation was performed by Versar, Inc. This study involved the installation of groundwater monitoring wells, with groundwater, surface water, and stream sediment sampling at each of the two locations. The objectives of the water quality impact study were to document contaminant releases and to characterize the extent of any hazardous substances migration. Versar collected samples of groundwater, surface water, and stream sediment from both Site 1 and Site 2 during three sampling events in March, May, and July 1988.

The study concluded that groundwater at Site 1 was contaminated by volatile organic compounds (VOCs) and sediments were contaminated with pesticides. At Site 2, the investigation had focused mainly on the oil separator pit, and results indicated that a ditch draining from the pit into an adjoining creek was contaminated with petroleum hydrocarbons, and that polyaromatic hydrocarbons (PAHs) may have entered into groundwater.

The Navy initiated Interim Remedial Measures (IRM) at both sites prior to completion of the RI/FS report. IRM refers to all removal actions conducted by OHM Remediation Services Corporation (OHM). From July 1994 through June 1995, OHM performed delineation of contamination (see Figure 1-2), removed contaminated soils and sediment from both sites, capped the Site 1 landfill and conducted confirmation sampling. The removal of the contaminated soil and sediments resulted in a change in the data set used in the Human Health Risk Assessment (HHRA) and the Ecological Risk Assessment (ERA) at the two RI sites and, as a result, had an impact on the conclusions and recommendations presented in the RI report. These reports were subsequently revised and reissued as part of the Site RI (February 1999).

Surface water, groundwater, and sediment sampling occurred in 1991 and 1994. This work was performed prior to the development of the RI. Information and data obtained from these sampling efforts can be found in the RI. According to the Human Health Risk Assessment, using the latest OHM sampling data has confirmed a reduction in risk associated with soil and sediment exposures. These data were obtained in 1995. Since then, groundwater is expected to have contamination concentrations declining and the sediment contaminant levels are expected to be lower due to stream erosion. This is also expected to favorably impact the surface water.

### 1.2.5 Individual Site Histories

#### 1.2.5.1 Site 1 - Old Landfill

In 1987, Atlantic Division, Naval Facilities Engineering Command (NAVFACENGCOM), identified the Old Landfill (Site 1) as a solid waste landfill. It operated from 1942 until base closure in 1976. The disposal activities were unregulated and the landfill is unlined. In 1968, the Atlantic Division, NAVFACENGCOM recommended pesticides be disposed at this site. Three pits were located in the southwest part of the landfill and one was located in the western part. These pits were used for disposal of liquids. Records of disposal for potentially hazardous wastes were not kept. However, it is known that, after the NTC was formally closed, building debris from the demolition of transite-clad (containing asbestos) structures was placed on the surface of the northern end of the landfill and covered with a minimal soil cover. By the time of the initial site inspection in 1988 (Versar, 1988), the landfill was largely covered by a growth of small trees, shrubs, and forbes. The areal extent of the disposal activities covered approximately 15 acres. The landfill was cleared and the waste was consolidated into a smaller area and covered by a RCRA Subtitle D-style cap including an impermeable membrane as an IRM.

The Old Landfill is located on the northwestern boundary of the NTC, separated from Route 276 by the facility fence and a small, unnamed stream. Review of the site topography reveals Site 1 is located on the southeast side of a deeply-incised stream valley leading up from the Susquehanna River flood plain at Port Deposit. A tributary to the stream along the road has cut a small valley on the southeast side of the landfill, so that the landfill is situated on the ridge between the two streams. The landfill was formerly tree-covered, but this has changed as a result of remediation activities. The landfill area was cleared and grubbed, and an additional 20 acres were cleared for access roads, borrow pits, waste excavation, and storm water facilities. Excavated soils from Site 2 and the pits within the landfill were placed in an IRM cell reserved for contaminated materials. The surface of this cell was graded and borrow material added to provide a clean surface for the placement of the IRM landfill cover.

The landfill delineation investigation revealed several areas of fill that were outside the suspected landfill boundaries. An area southwest of the road at the base of the suspected southwest landfill boundary contained building debris and what appeared to be discarded appliances. The northeast side of the landfill was extended to include additional detected landfill material. The northwestern boundary of the landfill was assumed to be the toe of the steep slope of visible rubble that bordered the stream at the base. It was later determined by OHM that wastes were present on the other side of the stream, adjacent to Route 276 near well 1-GW-2.

A location 190 feet north and 150 feet east of 1-GW-5 was identified as being on a fracture zone running southwest, essentially parallel to Route 276, and close to the southeast side of 1-GW-5. Wells 1-GW-8 and 1-GW-9 were installed at this location. This direction of fracturing is interpreted as being the cause of the dominant direction of enhanced hydraulic conductivity and anisotropic groundwater flow in this site. The landfill is underlain by a variable thickness of saprolite which grades at depth to competent fractured bedrock. Depth of bedrock surface ranges from approximately 20 to 30 feet below ground surface. In general, groundwater from the interstream uplands discharges to the adjacent streams in the form of baseflow, which maintains flow in the streams during prolonged periods without precipitation. Therefore, the streams and underlying fracture zones are strong hydrogeologic boundaries that constrain the migration of contaminants in groundwater from the landfill.

This conceptual model of groundwater flow (i.e., discharge to the adjacent streams and their underlying fracture zones) is confirmed by detection of landfill contaminants in groundwater seeps discharging to the streams down-gradient of the landfill. In addition, a cluster of wells installed as far down-gradient as possible, in the major fracture zone parallel to Route 276, has also intercepted landfill contaminants migrating in this fracture zone. This major fracture zone runs downhill parallel to Route 276 and intersects the Susquehanna River paleochannel deposits at the town of Port Deposit. Directions of groundwater flow are best determined by analysis of hydraulic head gradients and distribution of contamination, as the contaminants can be used as tracers. It is clear that in general all contaminants from the landfill at Site 1 will discharge to the streams on either side of the landfill, or to the fracture zone along Route 276 and then southwest towards the Susquehanna River.

Soils in the vicinity of the Old Landfill site are a complex mixture of Manor loam, Montalto silty clay loam, Woodstown sandy loam, and Chester silt loam (USDA 1973). The upper reaches of the streams on either side of the landfill are underlain by Baile silt loam. The lower reaches of the streams (i.e., downstream of the landfill) are mapped as Glenville silt loam. The landfill itself is mapped as Made Land. A small area of Made Land is noted along Route 276 partly under the site of the rubble landfill, but is not necessarily fill, and may only represent land disturbed during road construction.

### 1.2.5.2 Site 2 - Fire Training Area

The Fire Training Area (Site 2) is located within the southeast corner of the NTC and is bounded by Happy Valley Branch on the southeastern border of NTC property and Maryland Route 222. The site was used to train Navy recruits in firefighting techniques from the 1940s until the late 1960s. Site 2 consisted of three brick and reinforced concrete buildings set in line on the southwest corner of a large square concrete pad, with an adjoining clay-lined oil separator pit, southeast of the pad. There were also underground storage tanks (USTs) (10 in all) associated with the training activities that occurred on the concrete pad and one used to store heating oil for the former administration building northwest of the pad (OHM 1996a). When used for firefighting training purposes, the buildings were sprayed with oil and ignited (Versar 1989). The fire in the buildings was extinguished with water, and the oil and water run-off drained into two subsurface concrete vaults off the southwest corner of the pad.

The Fire Training Area was constructed on the gently sloping northwest bank of Happy Valley Branch, at an elevation ranging between 240 and 275 feet AMSL. The concrete pad on which the actual fire training was performed measured approximately 400-feet by 400-feet and sloped to the southeast towards a collection ditch and oil separator pit that measured approximately 200-feet by 200-feet. The pit was located adjacent to the southeast edge of the pad, between the pad and the creek. It was determined that initial drainage of oil and water off the pad was into two concrete subsurface vaults off the southwest corner of the pad. Overflow from these vaults went into the oil separator pit. Water from the separator pit drained through a subsurface valve and piping system discharging to a shallow ditch leading 250 feet to Happy Valley Branch. A barrier built of steel railroad track and wood across the creek and approximately 100-feet below the discharge of the separator pit had partially dammed the creek allowing sediment to accumulate behind it, raising the creek bed approximately five feet. Bed sediment in the Happy Valley Branch ranges from sand to gravel to cobbles. Happy Valley Branch passes under Route 222 via a culvert as it exits the NTC.

The bedrock under the site is a combination of fine-grained Port Deposit Gneiss separated by a thrust plane from the Happy Valley Branch Member of the James Run Formation to the south. Most of the site is mapped as "Made Land" due to disturbance during construction of the pad and oil separator pit, and the disturbed area extends over the former alluvium of the Happy Valley Branch flood plain to the edge of the stream. On the northeast side of the pad is Glenelg silt loam, with Glenville silt loam lower down the slope. The wetland east of the pad is in mixed alluvium of the flood plain. On the southwest side of both pad and separator pit is Manor loam, whereas mixed alluvium extends along the stream both above and below the site.

Sediments close to the site in Happy Valley Branch are coarse sand and gravel. Fine-grained sediments were sampled because of the affinity for contaminants to sorb to the finer-grained materials. Although no geotechnical (i.e., grain size) analyses were conducted to confirm this fact, it is anticipated that samples were comprised primarily of sediment with size ranges lower that those typically encountered in Happy Valley Branch. The wetland between Site 2 and Happy Valley Branch was characterized as part of a wetlands delineation program (E & E 1994b). The wetland is formed by drainages and seeps that drain slowly to the southeast where they become incorporated into the flood-plain of Happy Valley Branch. Prior to remedial actions, the area was in a heavily disturbed area, of low ecological value. A narrow riparian wetland was identified along the outflow of the oil separator pit.

In 1988, the fire training area was identified as requiring a hydrogeological investigation under the Navy Installation Restoration Program. The oil separator pit was the focus of this investigation. Groundwater, surface water, and sediment samples were collected. Five monitoring wells (2-GW-1,2,3,4,5) were installed on the perimeter of the oil separator pit in February 1988. Four additional wells were installed during the 1991 study, at suspected areas of contamination indicated by a soil gas survey conducted in 1991. Four more monitoring wells (for a total of 13 wells) were installed in 1993 to address gaps in the coverage of groundwater suspected to be migrating towards Happy Valley Branch. Four of the 13 wells were completed above bedrock at Site 2; 2-GW-3, 2-GW-6, 2-GW-9, and 2-GW-10, and nine were completed in fractured metamorphic rock described as Port Deposit Gneiss. The data show that 2-GW-1 is the up-gradient well and that groundwater flow from there is generally towards Happy Valley Branch to the south. The hydraulic conductivity data indicate that well 2-GW-12 has the highest hydraulic conductivity of any Site 2 well. This indicates a fracture zone of high transmissivity trending south towards the stream which is gaining from the groundwater.

Starting in October 1994, training structures on the fire training area pad and part of the concrete pad were demolished and removed. Approximately 24,000 cubic yards of contaminated soil from the separator pit, the drainage swales, and the separator vault area, were excavated and stabilized with portland cement or quarry dust. An additional 11,000 cubic yards were excavated from beneath the pad and 750 cubic yards of pesticide-contaminated soil were removed from the wetland area adjacent to the pad. These soils also were stabilized with quarry dust. All of the excavated and stabilized soil was transported to the newly established cell for investigation-derived waste materials in the Site 1 landfill prior to capping. The site was restored by placing clean fill from off site in the excavated areas. The site was returned to a topography for wetlands and clean drainage, and the area where the pad had been removed was re-vegetated in coordination with wetland specialists from the Maryland Department of Natural Resources. Clean fill was mixed with an imported compost material, placed in the separator pit, and graded to design specifications. The drainage swale was reconstructed with rip rap. The separator pit was replanted as an emergent wetland. The wetlands affected by pesticides were replanted with grass and trees native to the area (OHM 1996a). The riparian wetlands immediately adjacent to the present stream remained relatively intact. The demolition debris was placed into a special cell at the Site 1 landfill (OHM 1996a). Contaminated soil from the oil separator pit was excavated to depths of 4 to 5 feet below the original grade until confirmation samples collected had concentrations of TPH below the action level of 100 mg/kg (OHM 1996a). In addition to being analyzed for TPH, samples underwent analyses for halogenated VOCs, BTEX, pesticides, and metals.

## 1.3 Nature and Extent of Contamination

### 1.3.1 Site 1 - Old Landfill

Below is a summary of the analytical findings for groundwater, surface water and sediment sampling for Site 1 - Old Landfill. Further detailed information can be found in Section 3 of the RI. Screening values for individual analytes for each area sampled are also presented in Section 3 of the RI. Sample locations can be found in Figure 1-3.

Screening values are used to identify areas where contamination may exceed regulatory levels. Screening values aided in characterizing contamination, but did not eliminate from consideration positive detections that fell below screening values. Screening values cannot be used to determine whether or not a contaminant is migrating in the environment. The screening values were constructed from Applicable or Relevant and Appropriate Requirements (ARARs), and nonpromulgated advisories, guidances, or other values that are To Be Considered (TBC); and, in the case of metals, to background concentrations. Screening values were selected for each analyte from these values based on the following method: the lowest, non-zero ARAR was chosen; if no ARAR existed, then the lowest TBC was chosen. Finally, no screening value was set below the background concentration; therefore, if the background concentration was higher than the selected screening value, then background was used as the screening value (with the exception of soil samples).

#### 1.3.1.1 Groundwater

#### Inorganics

A variety of metals were detected in the groundwater at Site 1, but most were below screening values. Calcium, iron, magnesium, potassium, and sodium were all detected consistently above screening values. However, there are no regulatory action levels associated with these metals; all of their screening values are based on background levels by averaging the detections over ten sample rounds from locations 1-GW-1 and 2-GW-1. These five analytes are all common, naturally occurring metals. Chromium, cadmium, thallium, and nickel exceeded their screening values, but infrequently. Elevated manganese concentrations at wells 1-GW-3, 5, 8, and 9 appear to represent site-related contamination, based on the sampling locations being down-gradient of the site. No other inorganic contaminants were consistently detected at elevated levels the down-gradient wells.

### Organics
During the groundwater sampling rounds, 15 VOCs, 12 base-neutral-acid extractable compounds (BNAs), two pesticides and total petroleum hydrocarbons were detected in at least one of the 13 wells at Site 1. However, most of these compounds were detected below screening values. Compounds that were detected above their screening values include: 1,2-dichloroethylene (1,2-DCE), chlorobenzene (CB), trichloroethylene (TCE), vinyl chloride, and bis(2-ethylhexyl)phthalate. Most of the sampling data suggests that the source of these compounds is somewhere within the landfill and that they have been migrating to the south-southwest, with the groundwater.

## 1.3.1.2 Surface Water
### Inorganics
Surface water samples were taken from the creeks north of and on either side of the landfill. One creek is located north of the parade building ground and "H" building and is unaffected by the Old Landfill, one is located along the southwestern side of the landfill, and one is located along the northwest side of the landfill. The latter two creeks join southwest of the landfill. Contaminants in the surface water from these two creeks may be indicative of migration from the seeps observed adjacent to the landfill.

The following metals were found to exceed screening values: antimony, arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc. In most cases, either the exceedances were slight, or they were only consistently above the screening value for a given metal under base-flow conditions. This could indicate natural origin. However, two samples which were collected from the seeps located on the landfill side of both creeks show elevated metals. Many of these metals, such as arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc, could plausibly be attributed to typical waste disposal practices. Since these two seeps were found to have organic contamination (see below) similar to the groundwater sampling from wells down-gradient of the landfill, this indicates probable leachate discharge to the surface water system.

### Organics
Detection of organic compounds in Site 1 surface water were infrequent. The only VOCs to exceed screening values were chloroform and TCE. TCE is believed to be associated with leachate discharge as most of the results with elevated concentrations were from samples at 1-SW-16, which is from a seep along the southeastern creek. TCE was also detected in 1-SW-14 and P1-SW-11 (colocated in the southeastern creek just upgradient of the convergence), and P1-SW-4. TCE was also detected in well 1-GW-6,

which is several hundred feet up-gradient of the seep, indicating that this surface water contamination probably is due to groundwater contaminated with leachate. Chloroform was detected in several other surface water samples at concentration below the screening value, but it was not detected in groundwater samples.

The only BNA detection of significance was for 1,4-DCB. The concentrations were not high (no screening value exists for 1,4-DCB); however, 1,4-DCB was detected in several of the wells.

The only pesticides detected were DDT, DDE, and DDD (all in 1-SW-8) with levels near their screening values. In summary, it appears that most surface water contamination does not exceed screening values, but there are organics which are reflections of leachate migration through groundwater.

### 1.3.1.3 Sediment

#### Inorganics

Both creeks surrounding the landfill receive groundwater discharge and seeps were observed at the base of the landfill before the IRM was completed. Contaminants in the sediments may partially reflect contaminant migration from the landfill, but may also be influenced by surface water transport of other compounds present in the entire basin, such as pesticides. Four metals were consistently detected above soil screening values: arsenic, barium, beryllium, and manganese. The sediments were screened against soil criteria due to the absence of any agreed upon sediment screening values. Arsenic and beryllium both have screening values based on Environmental Protection Agency risk- based concentrations because of carcinogenic effects and they are each below the detection values and below the average levels for soils in the Eastern United States. The levels of these two analytes were extremely consistent, even in up-gradient samples, indicating that they are background values. Barium and manganese were also detected with consistency. For the most part, their detections were less than twice their screening values and these levels are probably background also. Two other metals were detected above screening values: nickel and chromium. Nickel exceeded its screening value in P1-SD-6, P1-SD-9 and P1-SD-11, all near the confluence of the two creeks; in 1-SD-1, 1-SD-6 and 1-SD-7, all in the northwestern creek, near 1-GW-2; and in 1-SD-11, the sample location that is the most downgradient and also is off site. Based on the locations of the nickel detections, it appears that it could be the result of a source within the landfill. Chromium was also detected in down gradient wells. The location of these wells implies that there could be a source of chromium in the landfill.

### Organics

Several VOCs were detected in sediment samples. PCE and TCE were detected in samples retrieved from seep locations on the southeastern creek. TCE and PCE were also detected near the pits in the Old Landfill. However, it is unlikely that groundwater from under the three pits would discharge to the southeastern creek. So other source areas may occur within the fill.

A number of PAHs were detected in the sediment samples taken in February, 1991. However, PAHs were not detected or showed only very low levels when resampling occurred in August, 1991. The sediment from the location where the samples were collected may have been transported off site by stream flow, which could explain why the contaminants were not detected again later that year. These creeks receive discharge from roads along much of the base. PAHs were detected in many of the pit soil samples, which can be attributed to the wastes (petroleum products) that were allegedly disposed in the pits. PAHs (Naphthalene and Anthracene) were occasionally detected in groundwater at the landfill, but at low levels which did not drive the risks in this area. In general, there does not appear to be any pattern in the contaminant concentrations. This is fairly typical of the localized randomness of PAH detections, and could indicate that this contamination is not directly related to the landfill. It appears more likely that it is a result of basewide vehicular use and other combustion sources including off-site sources.

Pesticides were detected in the Site 1 streambed sediments. DDT, and its two degradation derivatives DDD and DDE, were the most widespread detections. These analytes were detected in the background samples suggesting that these contaminants are the result of NTC facility-wide pesticide application, rather than disposal practices at the landfill. However, these pesticides were detected at much higher concentrations in the pit soil samples in the landfill indicating disposal at the landfill.

In summary, the only consistent repeated detections involved PAHs and the pesticide DDT and its degradation compounds. It appears that these contaminants reflect installation-wide conditions rather than landfill-specific disposal practices. Several VOCs were also detected, which would be more likely the result of contaminant migration from the landfill, but these were only found in February 1991 and not in later sampling events.

### 1.3.2 Site 2 - Fire Training Area

Below is a summary of the analytical findings for groundwater, surface water and sediment sampling for Site 2 - Fire Training Area. Further detailed information can be found in Section 4 of the RI. All of the screening values can also be found in the RI. Sample locations can be found in Figure 1-4.

#### 1.3.2.1 Surface Soils

Sixteen samples were taken in 1994 as a result of pesticide contamination found in the swale leading from the northeastern corner of the concrete pad to Happy Valley Branch. One sample was collected east of Happy Valley Branch to serve as background. The remaining samples were sited to provide approximately evenly spaced samples around the swale. Six of the samples showed high concentrations of pesticide contamination. These sample locations were along a linear configuration running northeast to southwest approximately 100 feet northwest of the creek. Based on these results, OHM sampled these soils extensively in July, August, and September 1994 to delineate the area requiring removal. Pesticide concentrations were highest in the samples taken within about 100 feet of Happy Valley Branch, on both the north and south sides of the drainage ditch. OHM then conducted an Interim Removal Action (IRM) involving the soils along the length of the drainage ditch from the concrete pad to Happy Valley Branch, as well as areas north and south of the ditch near Happy Valley Branch. Excavation continued to a depth of up to four feet in some areas until confirmation sampling showed no exceedances of Region III Risk Based Concentration (RBCs). Based on the IRM removal action and confirmation sampling performed by OHM, the pesticide-impacted soils have been remediated to below screening values and no longer represent a threat to human health and the environment.

#### 1.3.2.2 Subsurface Soils

**Organics at Separator Pit**

Samples were taken from four borehole locations within the oil separator pit. Analysis showed concentrations similar to waste petroleum material, which was expected given the usage of the pit. All four boreholes showed concentrations of TPH decreasing with depth. These samples also showed PAH contamination. All detections were below screening values, but the presence of ethylbenzene and xylene is indicative of waste petroleum products. During the IRM and prior to the actual removal, OHM conducted subsurface soil sampling from the floor of the pit and on the sides of the pit that confirmed TPH concentrations. During the removal action, OHM conducted confirmation sampling and continued to remove contaminated soil until the TPH concentrations were below 100 mg/kg. All other detections of organics were below established cleanup levels for the IRM and the residual oil contamination in the pit has been removed.

### Concrete Vault Area

One borehole was drilled to a depth of 15 feet and revealed contamination typical of a subsurface source of waste oil with the highest contamination in the deepest sample (from 10 to 15 feet). Twelve other PAHs were detected in this sample and ethylbenzene and xylenes were also detected, but below their screening values. As directed by EFA-Chesapeake, the concrete oil/water separator vaults on the southwest side of Building C were demolished and the concrete debris and surrounding petroleum-impacted soils were removed and transported to the Site 1 landfill for disposal as part of the IRM. Soil contaminated with hydrocarbons were excavated to soil cleanup goals for TPH or to competent bedrock, whichever was encountered first. Confirmation sampling results were used above the water table to determine the limits of excavation. Since collection of soil samples below the water table is not an accepted practice, contaminated soils below the water table were removed to competent bedrock without confirmation soil sampling.

### Inorganics

The five boreholes discussed above were also sampled for inorganic analytes. Only three metals were found above screening values: arsenic, barium, and manganese. Barium and manganese were detected consistently in these samples and the levels appear to reflect their background levels. Arsenic was detected only in the surficial samples. Lead concentrations also were higher in these surficial samples but below screening values. However, OHM removed all of the soil based on TPH contamination during the IRM conducted in 1994. OHM did not sample for metals in their confirmation samples, but surficial soils and subsurface soils were removed up to a depth of four feet. Therefore, it is highly unlikely that there is elevated arsenic or lead remaining as a result of site-related activities.

#### Pesticide Impacted Wetlands

An additional eight boreholes (2-BH-5 to 2-BH-12) were drilled in March 1994 to evaluate subsurface pesticide levels for remediation in the wetland area northeast of the oil separator pit and east of the concrete pad. Borehole locations were spaced to define the extent of pesticide contamination, identified in sediment samples collected in this area in 1991. The boreholes were drilled using a two-man power auger with six inch outer diameter solid stem auger flights. Samples were collected from cuttings removed from the deepest part of each boring. The results in the boreholes were similar to those found in the eight surface soil samples with which these were colocated. This area has been remediated by OHM and pesticide contaminated soils have been excavated. Confirmation samples collected by OHM showed that pesticides had been removed to below the Region III RBC (OHM 1996).

### 1.3.2.3 Groundwater

#### Inorganics

Nine monitoring wells were installed at Site 2 in 1991. A variety of metals were detected in the groundwater at Site 2, mostly below screening values. Calcium, iron, magnesium, potassium, and sodium were all detected consistently above screening values in several wells. However, there are no regulatory values associated with these metals; all of their screening values are based on background levels. These five analytes are all moderately soluble naturally occurring metals, which generally are not considered groundwater contaminants. It is unlikely that elevated concentrations of these metals are a result of activities at the Fire Training Area. These levels are not considered a human health problem, and remedial action is generally not performed for these analytes. Manganese was also frequently detected at concentrations exceeding its screening value, which is based on a RBC. Manganese is also a naturally occurring metal, often associated with iron, but the concentration distribution of manganese is consistent with a site-related contaminant. The other metals exceeding screening values included: antimony, zinc, cadmium, and beryllium.

#### Organics

In general, detections of organic contaminants in groundwater were low except in one well (2-GW-8). Concentrations of organics indicative of petroleum contamination were found in the soil around this well location and excavated, and the well was removed.

Screening values were exceeded in at least one sample round for the following contaminants, all of which are PAHs: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, indeno(1,2,3-cd)pyrene, and naphthalene. Detections of these compounds (except for the lighter compound naphthalene) were fairly low but above their corresponding screening values. Naphthalene was detected in six of the sample rounds and was at times higher than the lifetime health advisory level. Other PAHs that do not have MCLs were detected and did not exceed screening values. TPH was detected in 2-GW-8. There is no screening value, but this corroborates the PAH detections and suggests that the PAHs in this well are associated with oil. In addition, ethylbenzene and xylenes were detected at levels below their respective MCLs. In addition to petroleum-related compounds, well 2-GW-8 exceeded the screening value for aldrin, a pesticide, but it was only detected in one sample round, indicating that this detection reflects at most very sporadic conditions.

TCE was detected consistently in 2-GW-2, although it never exceeded its screening value. This well is located approximately 100 feet to the east of the separator pit and may reflect contaminant migration from the separator pit. Well 2-GW-4 revealed detections of TCE, 1,1,2,2-TCE, 1,2-DCE, and CB below their respective MCLs. This well, approximately 150 feet south of the oil/water separator pit area may also reflect contaminant migration from the pit.

Methylene chloride was detected above its screening value. However, these exceedances occur only once in three of the wells. Methylene chloride was noted in several samples, but as it is a common laboratory contaminant and was noted only sporadically, it is probably not site related.

Several phthalates were detected sporadically also in these wells. Once bis(2-ethylhexyl)phthalate was noted above its screening value. These plasticizers are common sampling and laboratory contaminants. It is unlikely that they are actually present in the groundwater because they sorb strongly to soils.

#### 1.3.2.4 Surface Water

**Inorganics**

Seven metals were detected above screening values in surface water samples: arsenic, cadmium, chromium, copper, lead, mercury, and zinc. Almost all of the detections were from three samples; the first two were taken in the swale draining the concrete pad, and the third was in the swale draining the separator pit. The concentrations of these seven metals, as well as for aluminum, barium, beryllium, cobalt, iron, manganese, nickel, and vanadium were much higher in these samples than in the others, which were all taken from Happy Valley Branch. Therefore, it is likely that these detections reflect contamination associated with activities at the Fire Training Area. However, sediments from these swales were excavated as part of the IRM performed by OHM and can no longer affect surface water.

**Organics**

Very few organics were detected in surface water samples. Bis(2-ethylhexyl)phthalate was detected at all of the surface water locations in only one sampling round. Although the detections exceeded screening values, this is not considered contamination of significance. Phthalate compounds are ubiquitous plasticizers and are common sampling and laboratory contaminants; and their presence in one sampling round only indicates that this is what they were.

The only other organics detected above screening values were DDT, and its degradation compounds DDD and DDE. All detections were above the human health screening value for protection against consumption of water and organisms. All of the detections, except for one, were in samples taken from two locations in the swale leading from the northeast corner of the concrete pad to Happy Valley Branch. This area has been remediated. No organic contaminants of significance were detected in surface water samples taken from Happy Valley Branch.

#### 1.3.2.5 Sediment

**Inorganics**

Four metals were detected above screening values in Site 2 sediments: arsenic, barium, chromium and manganese. Arsenic exceeded its screening value in every sample, both upgradient and downgradient. Therefore, it appears this represents the background level of arsenic and not site-related contamination.

Chromium was found in one sample and manganese was found in three samples with each exceeding screening values. Barium was detected in five samples from three locations. The first two locations were in the swale draining the concrete pad and also showed organics contamination of significance. The third sample was taken in Happy Valley Branch, downgradient of this swale. It is possible that barium reflects site-related contamination. However, sediments from these swales were removed by OHM. Therefore, it is unlikely that these metals represent a current or future problem in the sediments at Site 2.

**Organics**

Pesticides and PAHs were detected in sediments at Site 2. However, all of the detections above screening values were in the two swales that were excavated by OHM as part of the interim action. Pesticides were detected at concentrations below screening values in samples taken from Happy Valley Branch upgradient of Site 2. PAHs were also detected in some of these samples, again below screening values. Therefore, this contamination appears to reflect the installation-wide use of pesticides, and widespread presence of PAHs, which result from the incomplete combustion of petroleum products.

The only organic contamination that can be attributed to site-related activities, and that posed a threat to human health; was in the swales. Sediments from the swales were removed and placed at the Site 1 landfill. Confirmation sampling was performed after removal.

## 1.4 Risk Assessment

### 1.4.1 Human Health Risk Assessment

The baseline HHRA focuses on potential risks to human receptors posed by environmental contamination related to Sites 1 and 2 at the NTC. The development of the HHRA can be reviewed in Section 5 of the RI Report. One of the objectives of the HHRA was to review the site characterization data available from both the RIs and OHM's subsequent removal actions and identify site-related COPCs in each exposure medium. Risk-based screening concentrations were used to eliminate chemicals that were considered unlikely to contribute significantly to overall site risks. The remaining Chemical of Potential Concern (COPCs) were carried through the quantitative assessment, whereby estimated exposures were combined with toxicity values developed by EPA to estimate the magnitude of risks posed by site contamination.

EPA continually reviews new toxicity information and periodically updates the toxicity values in its databases. Since the risk assessment was prepared, toxicity values for a number of chemicals found at the Bainbridge sites have been revised or newly developed by EPA, and one value (the oral cancer slope factor for beryllium) has been withdrawn. As a consequence, current estimates of risks associated with some COPCs are different from the estimates in the risk assessment. Furthermore, due to corresponding changes in risk-based screening concentrations (RBSCs), a few chemicals that were eliminated from the quantitative risk assessment are now being reconsidered as COPCs. In comments on the draft feasibility study (See Appendix F), EPA has outlined changes in toxicity values and the impacts on COPCs identified and risk-based cleanup goals. Those changes have been incorporated in the calculations of risks and risk-based cleanup goals for this feasibility study.

Table 1-1 (revised from Table 5-9 in the RI report) lists COPCs based on screening with updated RBSCs (RBSCs differ from previously described screening levels in that RBSCs consider only risk, not background concentrations or ARARs). Tables 1-2 and 1-3 summarize updated estimates of cancer risks and non-cancer Hazard Indices (HIs) respectively, for Sites 1 and 2. Substantial changes in numbers from summary tables in the human health risk assessment (RI Tables 5-25 and 5-26 in the human health risk assessment) are noted and explained in table footnotes.

The HHRA concluded that the major factors driving the estimated site risks are the possible use of groundwater as a future drinking water source. The revised risk summaries show that the groundwater at Site 1 poses a risk due to the presence of chloroform, iron, antimony, thallium and manganese. However, vinyl chloride and TCE also exceeded their MCLs. At Site 2, the risk is due to the presence of carcinogenic PAHs (mostly benzo(a)pyrene), thallium, chloroform, iron, and manganese.

Groundwater is used as a water supply source by residents outside the Port Deposit town limits. However, there is no evidence that existing water supply wells outside the NTC have been affected by site contamination. Future exposure to groundwater contaminants could conceivably occur only if new water supply wells were installed within the affected areas. Proposed future plans for the facility potentially include development of some areas for light industrial, commercial, recreational, and/or residential uses.

### 1.4.2 Ecological Risk Assessment

A Desktop Ecological Risk Assessment (DERA) was performed by the U.S. Fish and Wildlife Service in October, 1998. The report is included in the RI. The Desktop ERA evaluates risk due to contaminated sediment for four different ecological receptors by two different methods: toxicity tests and food-chain models based on ingestion of surface water and sediment by birds (the kingfisher) and mammals (the racoons).

The risks associated with each site are based on the potential to impact ecological receptors. At the Old Landfill, risks were inferred for all the ecological receptors; benthic life, fish, piscivorus birds, and omnivorous mammals. At the Fire Training Area, risks were inferred for piscivorus birds and omnivorous mammals only. Each of these risks are based on sampling results of sediment and surface water and on food-chain modeling.

There is some uncertainty associated with these risks due to the fact that these risks are based on data that was gathered only as recently as 1994. Also, remediation activities have changed the characteristics of the NTC Sites and contaminated media, particularly sediments.

## 1.5 Remedial Investigation Items

During the review of the RI several items were left for clarification in this FS report. These items included beryllium no longer being considered as a COPC, the effect of metals-contaminated blank samples on potential clean-up goals, and the evaluation of background sediment results.

### 1.5.1 Beryllium

The oral slope factor for beryllium was withdrawn from EPA's Integrated Risk Information System (IRIS) database in April 1998. Therefore it will not be considered a COPC for the NTC sites. Table 1-1, Summary of Cancer Risks Associated with the Bainbridge NTC - Reasonable Maximum Exposures; and Table 1-3, Summary of Chemicals of Potential Concern, have been adjusted from the RI to reflect this.

### 1.5.2 Blank-Sample Contamination

Several metals were detected in groundwater field blanks and method blanks. The data presented in the RI was appropriately qualified based on the level of contamination found. Manganese and iron are COPCs which are of most concern. The levels of contamination by these two metals, and others, in the blanks are low, typically less than

100 $\mu$g/L. Manganese was found in blanks at concentrations up to 7.4 $\mu$g/L and iron was found up to 100 $\mu$g/L. These levels will be compared against proposed cleanup goals developed in Section 2 to determine if they pose a significant impact on the proposed cleanup goals.

However, other risk drivers found in blanks are not believed to be site groundwater contaminants. Thallium and chromium were found in blanks (up to 28 $\mu$g/l and 15 $\mu$g/l, repsectively). Thallium was detected only three times at Site 1 out of 113 samples analyzed, and has not been detected since the March 1994 sampling round (there have been six sampling rounds since March 1994). Thallium was only found in blanks associated with Site 2, but the Site 2 thallium levels would have been well within the blank-affected level (sample 2-GW-2 1 $\mu$g/l, sample 2-GW-11 1 $\mu$g/l, prep blank 1.1 $\mu$g/l). These were the only thallium detections (2) at Site 2 out of 105 samples analyzed. Thallium has not been detected at Site 2 since October 1994. Therefore, thallium in groundwater at Sites 1 or 2 is not considered a site contaminant.

Chromium was not detected above screening values except for two wells (1-GW-13 in January 1994 and 1-GW-2 in April 1991). Subsequent rounds of sampling, including the recent pre-ROD sampling, did not indicate chromium above screening values.

Based on the low overall frequency of detection and the fact that chromium and thallium have not been detected recently (above screening values for chromium), these chemicals do not appear to be site groundwater contaminants. Therefore they will not be considered as contaminants requiring remediation nor will preliminary remediation goals be developed.

### 1.5.3 Background Sediment

Background sediment data collected in 1997 for the Navy during Environmental Baseline Survey (EBS) sampling and background sediment data collected for the RI were used to derive background screening criteria. The data set included a total of six samples; two composite samples from the EBS (8-SD-1 and 8-SD-2 from upgradient of Sites 1 and 2, respectively),and four grab samples from the RI (collected in February 1991 and August 1991 from locations P1-SD-3 and P2-SD-5 upgradient of Sites 1 and 2, respectively). Site background screening concentrations were calculated for both organics and inorganic compounds, as the average plus two standard deviations for each analyte. These concentrations will be used to support development of preliminary remediation goals in Section 2. The background sediment data and screening concentrations are presented in Appendix A.

### 1.5.4 Site 2 Soils

Subsurface soils at Site 2 will not be addressed in this FS. Site 2 was subject to an IRM that removed significant portions of contaminated soils. The HHRA used analytical results from soil borings that were outside of the area of the IRM and only data from the upper ten feet of these borings. The highest estimated cancer risks attributable to the soils were calculated to be $3.3 \times 10^{-6}$. This risk is due completely to arsenic under the exposure scenario that allows residential construction to bring subsurface soils to the surface. Arsenic was found in site soils at similar concentrations to site background levels (1.1 mg/kg versus 0.62 to 1.0 mg/kg, respectively).

Estimated hazard indices (HIs) indicate that exposures to Site 2 soils are unlikely to cause any adverse noncancer health effects. The total HIs for residential exposure to soil at Site 2 are estimated to be 1.6 for the adult/child and 3.2 for the child, above the 1.0 benchmark level. However, because the soil COPCs affect different target organs, the individual chemical HIs are not considered to be addititive and, therefore, should be evaluated separately. The individual chemical HIs for the adult/child are all less than 1 and, except for chromium, the HIs for the child are also below 1. An HI of 1 was calculated for chromium using the maximum concentration detected and the RfD for the most toxic form, hexavalent chromium (Cr VI). This is almost certainly an overestimate, since chromium concentrations at the site are likely lower overall than the maximum detected and since the form of chromium in soil is more likely to be the less toxic, trivalent form (Cr III).

Therefore, the soils at Site 2 will not be addressed in this report; and because the levels found are typical of native soils, no statistical review of background soil data is warranted.

**Table 1-1**

**SUMMARY OF CHEMICALS OF POTENTIAL CONCERN (FROM HUMAN HEALTH RISK ASSESSMENT)**- Revised [b]

| Chemical | Site 1 Sediment | Site 1 Groundwater | Site 2 Sediment | Site 2 Subsurface Soil | Site 2 Groundwater |
|---|---|---|---|---|---|
| Aluminum | X | | | X | X |
| Antimony | | X | | | |
| Arsenic | X | X | X | X | X |
| Cadmium | | X | | | X |
| Chromium | X | X | | | X |
| Iron | X | X | X | X | X |
| Manganese | X | X | X | X | X |
| Nickel | | X | | | |
| Thallium | X | X | | | X |
| Vanadium | X | | | | |
| Zinc | | | | | X |
| Aldrin | | | | | X |
| Heptachlor | | X | | | |
| 1,4-Dichlorobenzene | | X | | | X |
| Acenaphthene | | | | | X |
| Acenaphthylene | | | | | X |
| Benzo(a)anthracene | X | | | | X |
| Benzo(a)pyrene | X | | | | X |
| Benzo(b)fluoranthene | X | | | | X |
| Benzo(k)fluoranthene | X | | | | X |
| Chrysene | X[a] | | | | X[a] |

**Table 1-1**

**SUMMARY OF CHEMICALS OF POTENTIAL CONCERN (FROM HUMAN HEALTH RISK ASSESSMENT)- Revised [b]**

| Chemical | Site 1 | | Site 2 | | |
|---|---|---|---|---|---|
| | Sediment | Groundwater | Sediment | Subsurface Soil | Groundwater |
| Naphthalene | X | | | | X |
| Phenanthrene | | | | | X |
| Dibenzo(a,h)anthracene | X | | | | |
| Indeno(1,2,3-cd)pyrene | X | | | | X |
| Dibenzofuran | | | | | X |
| Bis(2-ethylhexyl)phthalate | | X | | | X |
| 1,1,2,2-Tetrachloroethane | | | | | X |
| 1,2-Dichloroethene | | X | | | |
| 1,2-Dichloropropane | | X | | | |
| Chlorobenzene | | X | | | |
| Chloroform | | X | | | X |
| Methylene chloride | | X | | | X |
| Trichloroethene | | X | | | X |
| Vinyl chloride | | X | | | |

[a] Chrysene did not exceed its RBSC, but was included along with the other carcinogenic PAHs.

[b] COPCs were added or deleted based on updated toxicity information/new RCSCs. Accordingly, beryllium and chlordane have been dropped from the COPC list, while naphthalene, acenaphthene, acenaphthylene, phenanthrene, and dibenzofuran have been added as COPCs in Site 2 groundwater.

Table 1-2

**SUMMARY OF CANCER RISKS ASSOCIATED WITH THE BAINBRIDGE NTC - REASONABLE MAXIMUM EXPOSURES**

| Scenario | Receptor | Estimated Cancer Risk | Risk Contribution by Route | Risk Contribution by Chemical |
|---|---|---|---|---|
| **Site 1: Old Landfill** | | | | |
| Recreational Exposure to Sediment | Adolescent | 4.0E-07 | Sediment ingestion - 86%<br>Dermal absorption - 14% | Carcinogenic PAHs -72%<br>Arsenic - 28% |
| Residential groundwater use | Adult | 6.5E-05 [a] | Water ingestion - 63%<br>Vapor inhalation - 24%<br>Dermal absorption - 13% | Vinyl chloride - 31%<br>Arsenic - 28%<br>Chloroform - 10%<br>1,4-Dichlorobenzene - 12%<br>Di(2-ethylhexyl)phthalate - 9%<br>Heptachlor - 5%<br>Trichloroethene - 3% |
| | Child | 2.2E-05 | Water ingestion - 88%<br>Dermal absorption - 12% | Arsenic - 39%<br>Vinyl Cloride - 32%<br>Di(2-ethylhexyl)phthalate - 9%<br>1,4-Dichlorobenzene - 9%<br>Heptachlor - 4%<br>Trichloroethene - 2% |
| **Site 2: Fire Training Area** | | | | |
| Recreational Exposure to Sediment | Adolescent | 5.9E-08 | Dermal absorption - 51%<br>Sediment ingestion - 49% | Arsenic - 100% |
| Residential Exposure to Soil | Adult/child | 3.3E-06 | Soil ingestion - 59%<br>Dermal absorption - 41% | Arsenic - 100% |
| | Child | 1.8E-06 | Soil ingestion - 75%<br>Dermal absorption - 25% | Arsenic - 100% |
| Residential Groundwater Use | Adult | 3.0E-04 [b] | Water ingestion - 89%<br>Vapor inhalation - 9%<br>Dermal absorption - 2% | Carcinogenic PAHs - 75%<br>1,1,2,2-Tetrachloroethane - 9%<br>Arsenic - 7%<br>Aldrin - 3%<br>Chloroform - 3%<br>Di(2-ethylhexyl)phthalate - 2% |

**Table 1-2**

**SUMMARY OF CANCER RISKS ASSOCIATED WITH THE BAINBRIDGE NTC - REASONABLE MAXIMUM EXPOSURES**

| Scenario | Receptor | Estimated Cancer Risk | Risk Contribution by Route | Risk Contribution by Chemical |
|---|---|---|---|---|
| | Child | 1.3E-04 | Water ingestion - 98%<br>Dermal absorption - 2% | Carcinogenic PAHs - 83%<br>Arsenic - 7%<br>1,1,2,2-Tetrachloroethane - 5%<br>Aldrin - 2%<br>Chloroform - 2% |

[1] Estimated risks from 1, 4-dichorobenzene increased due to use of provisional inhalation SF.
[3] Inhalation risks from PAHs decreased due to use of lower provisional inhalation SF.

Key:

PAHs = Polynuclear aromatic hydrocarbons.
SF = Slope factor.

## Table 1-3

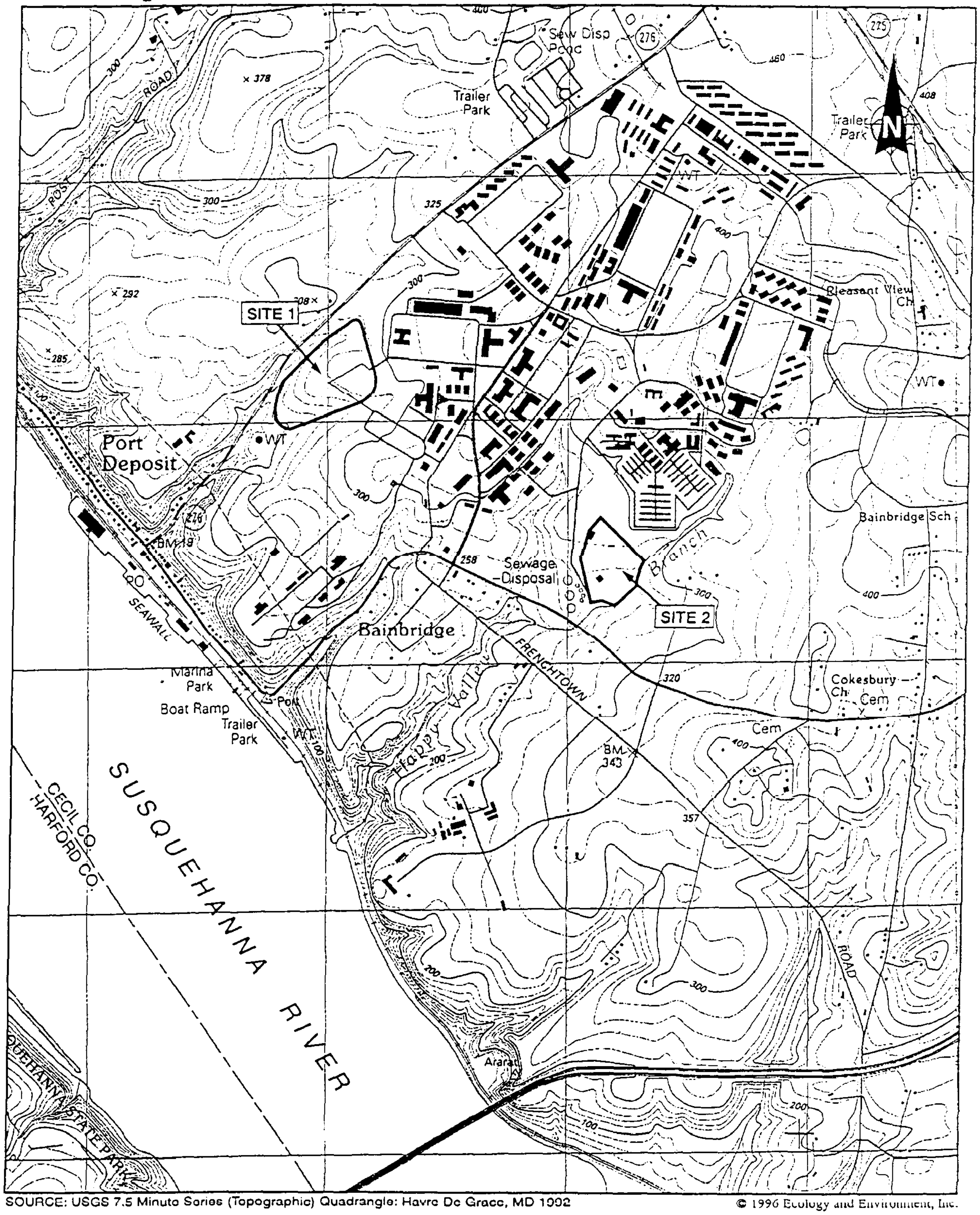
## SUMMARY OF NON-CANCER RISKS ASSOCIATED WITH THE BAINBRIDGE NTC - REASONABLE MAXIMUM EXPOSURES

| Scenario | Receptor | Estimated Hazard Index | Risk Contribution by Route | Hazard Index by Chemical |
|---|---|---|---|---|
| **Site 1: Old Landfill** | | | | |
| Recreational Exposure to Sediment | Adolescent | 0.08 [a] | Dermal absorption - 66%<br>Sediment ingestion - 34% | — |
| Residential groundwater use | Adult | 18 [b] | Water ingestion - 83%<br>Vapor inhalation - 14%<br>Dermal absorption - 3% | Manganese - 9.8<br>Iron - 2.2<br>Antimony - 2.1<br>Chloroform - 1.8<br>Chlorobenzene - 0.4<br>Thallium - 0.4 |
| | Child | 35 | Water ingestion - 98%<br>Dermal absorption - 2% | Manganese - 23<br>Iron - 5.2<br>Antimony - 4.9<br>Thallium - 0.9<br>Chlorobenzene - 0.4 |
| **Site 2: Fire Training Area** | | | | |
| Recreational Exposure to Sediment | Adolescent | 0.02 [a] | Dermal absorption - 61%<br>Sediment ingestion - 39% | — |
| Residential Exposure to Soil | Adult/child | 1.6 [c,a] | Dermal absorption - 73%<br>Soil ingestion - 26% | All below 1 |
| | Child | 3.2 [c,a] | Dermal absorption - 56%<br>Soil ingestion - 44% | Chromium - 1<br>Iron - 0.8<br>Manganese - 0.7 |
| Residential Groundwater Use | Adult | 19 [b] | Water ingestion - 84%<br>Vapor Inhalation - 15%<br>Dermal absorption - 1% | Manganese - 7.7<br>Iron - 7.2<br>Chloroform - 2.5 |
| | Child | 37 | Water ingestion - 99%<br>Dermal absorption - 1% | Manganese - 18<br>Iron - 17<br>Thallium - 0.9 |

Key:

a Dermal risks from iron decreased due to change in oral absorption adjustment factor from 0.1 to 1.
b Inhalation risk from chloroform increased due to new lower provisional inhalation RFD.
c Chromum added as COPC due to new lower oral RFD (for hexavalent form).

02: CD7171\CD7_11.CDR




SOURCE: USGS 7.5 Minute Series (Topographic) Quadrangle: Havre De Grace, MD 1992

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SCALE 1:24,000

0 ½ 1 Mile

0 .5 1 Kilometer

Figure 1-1 SITE LOCATION MAP, BAINBRIDGE NAVAL TRAINING CENTER, PORT DEPOSIT, MARYLAND

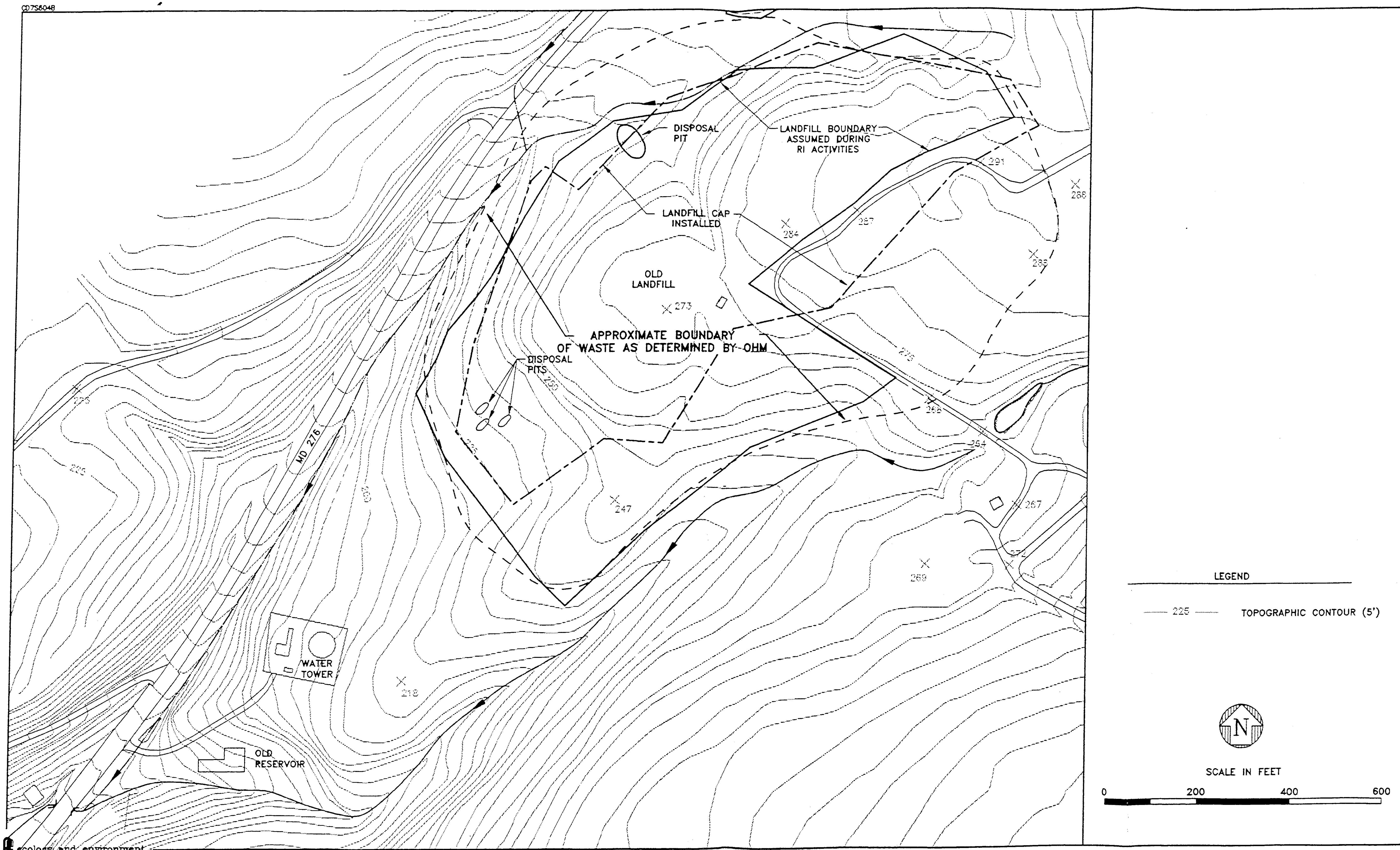


Figure 1–2 SITE MAP
SITE 1 – OLD LANDFILL PRIOR TO REMEDIATION
NAVAL TRAINING CENTER–BAINBRIDGE

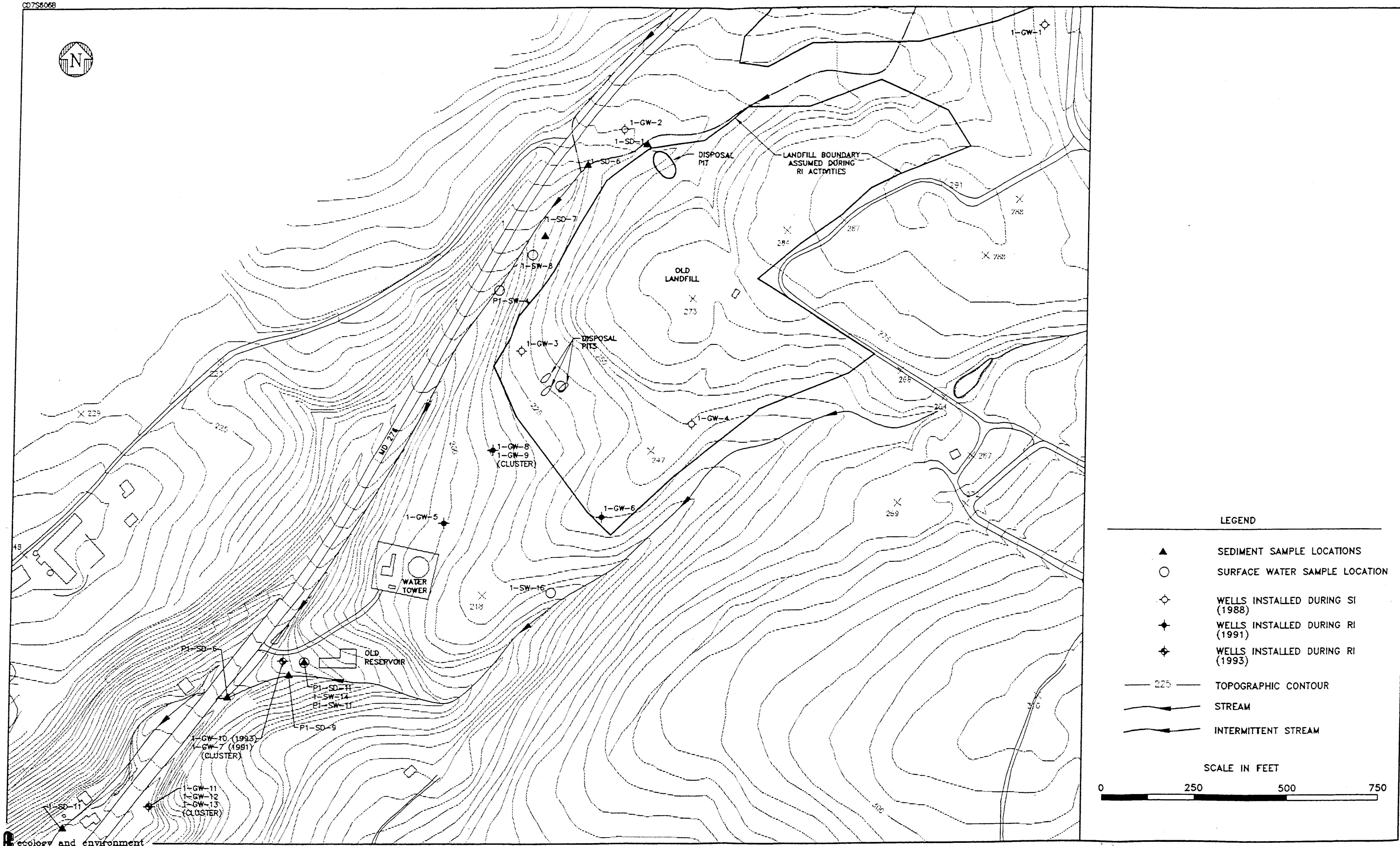


Figure 1-3 MONITORING WELL AND SAMPLE LOCATIONS
SITE 1 – OLD LANDFILL
NAVAL TRAINING CENTER BAINBRIDGE

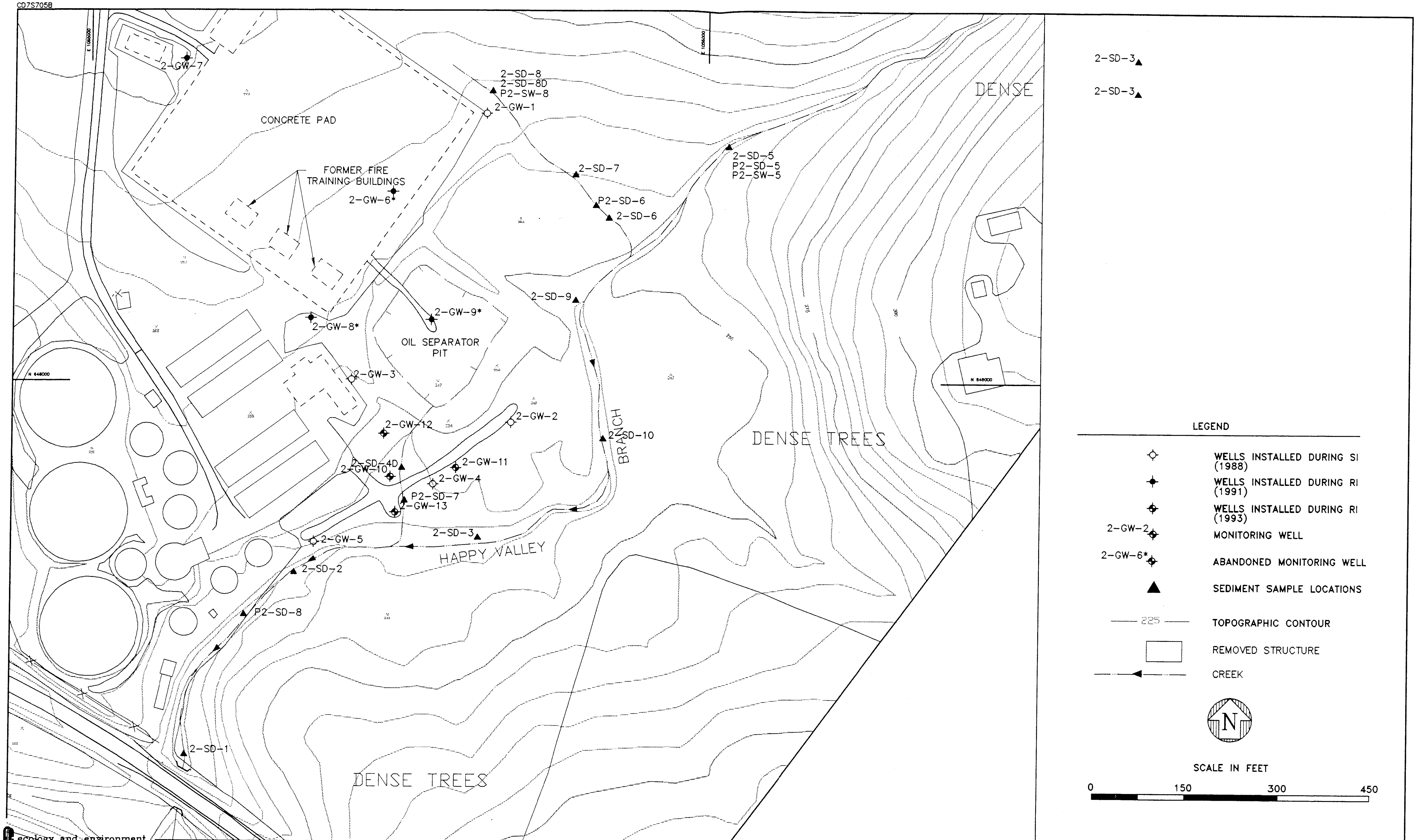


Figure 1-4 MONITORING WELL AND SEDIMENT SAMPLE LOCATIONS
SITE 2 - FIRE TRAINING AREA
NAVAL TRAINING CENTER - BAINBRIDGE

# 2 Development of Remedial Action Objectives, Clean-Up Levels, and Remedial Action Alternatives

## 2.1 Remedial Action Objectives

Remedial action objectives (RAOs) consist of medium- or operable unit- specific goals for protecting human health and the environment (EPA 1988). RAOs address specific contaminants of concern, exposure pathways and receptors, and acceptable contamination levels for each exposure route. In 1995, IRMs were conducted at both Sites 1 and 2 at the Bainbridge NTC. In preparing this FS, consideration is only given to those contaminants of concern remaining after the IRMs.

### 2.1.1 Site 1

Contamination remaining at Site 1, following the IRM, is present in groundwater as VOCs, SVOCs, inorganics, and pesticides; in sediment as SVOCs, pesticides, and inorganics; and in surface water as VOCs, SVOCs, TPH, pesticides, and inorganics.

The HHRA found the major factors driving the estimated site risks at the Old Landfill Site are the possible use of groundwater as a future drinking water source. The groundwater is contaminated with chlorinated hydrocarbons (Chlorobenzene, chloroform, trichloroethene (TCE), vinyl chloride (VC), antimony and iron. Thallium is not considered a site groundwater contaminant (see Section 1.5.2).

The Desktop ERA concluded that the major factors driving the ecological risks at the Old Landfill Site are pesticides, PAHs and metals in sediment and metals in surface water.

Because an IRM has already been implemented at this site (capping of the landfill), as well as the fact that the RI was written based primarily on data obtained prior to the IRM, the list of Site 1

COPCs to be evaluated in this FS will include only those remaining contaminants that are considered a risk based on the findings of the HHRA and the Desktop ERA.

The RAOs for this site are to reduce exposures to contaminants through each of the exposure routes to acceptable levels, either by blocking or restricting the routes of exposure or by reducing contaminant concentrations.

### 2.1.2 Site 2

An IRM (soil/sediment removal) was also implemented at Site 2. Contamination remaining at Site 2, following the IRM, is present in groundwater as VOCs, SVOCs, TPH, pesticides, and inorganics; and in sediment as inorganics; and in surface water as VOCs, SVOCs, TPH, pesticides, and inorganics.

The HHRA found that the major factors driving the estimated site risks at the Fire Training Area site are the possible use of groundwater contaminated with 1,1,2,2-tetrachloroethane, carcinogenic PAHs (primarily benzo(a)pyrene), iron, and manganese as a future drinking water source. Thallium is not considered a site groundwater contaminant (see Section 1.5.2).

The Desktop ERA concluded that the major factors driving the ecological risks at the Fire Training Area site are pesticides and metals in sediment. Surface water posed no ecological risks at this site.

Because an IRM has already been implemented at this site, as well as the fact that the RI was written based primarily on data obtained prior to the IRMs, the list of Site 2 COPCs to be evaluated in this FS will include only those remaining contaminants that are considered a risk based on the findings of the HHRA and the Desktop ERA.

The RAOs for this site are to reduce exposures to contaminants through each of the exposure routes to acceptable levels, either by blocking or restricting the routes of exposure or by reducing contaminant concentrations.

## 2.2 Definition of Contaminated Area of Concern

To define the area or volume of each medium that must be addressed to meet the RAOs, chemical-specific cleanup goals were developed for each medium at each site. The cleanup goals are developed based on an evaluation of applicable or relevant and appropriate requirements (ARARs) or other criteria and guidelines to be considered (TBCs), including findings of the HHRA and ERA. This evaluation will determine COPC levels that are deemed protective of human health and the environment.

The ARARs and TBCs presented in this report are in accordance with Section 121 (d)(2) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). They are also consistent with EPA guidance values set forth in the CERCLA National Contingency Plan (NCP) (40 CFR 300); the two-part document entitled CERCLA Compliance With Other Laws Manual (OSWER Directives 9234.1-01 [Draft], August 8, 1988, and 9234.1-02, August 1989); and the document entitled Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (EPA-540/G-89/004).

The RAOs identified in this report are preliminary and will be further refined as the remedial process proceeds and final remedial measures are identified. The main focus of this section is to identify chemical-specific ARARs, non-promulgated federal or state standards or guidance documents, and human health and ecological risk values that can serve as clean-up goals. The secondary purpose of this section is to identify action- and location-specific ARARs that may impact the screening and selection of remedial alternatives. Only those ARARs, TBCs, and risk values determined to apply to these sites will be discussed.

### 2.2.1 Applicable or Relevant and Appropriate Requirements

An ARAR may either be "applicable" or "relevant and appropriate." Applicable requirements are those substantive environmental protection standards, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, remedial action, location, or other circumstance at a given site. Relevant and appropriate requirements are those substantive environmental protection requirements promulgated under federal or state law that, although not legally applicable to the circumstances at the site, address situations sufficiently similar to those encountered at the site so that their use is well-suited to a particular site. Administrative requirements (e.g., obtaining permits and agency approval, record-keeping, reporting, and off-site activities such as disposal) are not included in the definition of ARARs.

There are three types of ARARs, including:

**Chemical-specific ARARs:** Usually health- or risk-based numerical values or methodologies that establish an acceptable amount or concentration of chemical in the ambient environment;

**Action-specific ARARs:** Usually technology- or activity-based requirements for remedial actions; and

**Location-specific ARARs:** Restrictions placed on the concentrations of hazardous substances or the conduct of activity solely because they occur in special locations.

Only chemical-specific ARARs address clean-up goals. Action- and location-specific ARARs will be discussed in Sections 3 through 5 of this report as they relate to specific remedial alternatives.

### 2.2.2 TBCs

TBCs are appropriate non-promulgated federal or state standards or guidance documents that are used in developing clean-up goals. Because they are not promulgated or enforceable, they do not have the same status as ARARs and are not considered required clean-up standards.

### 2.2.3 Risk Assessments

Because CERCLA requires that remedial actions be protective of human health and the environment, health and environmtental risk estimates from the site-specific HHRA and the Desktop ERA were considered in developing chemical-specific clean-up goals. EPA has adopted the policy that acceptable exposures to known or suspected carcinogens are generally those that represent an excess upper-bound lifetime cancer risk to an individual of between $10^{-4}$ and $10^{-6}$ (40 CFR300.430 [E][2][i][A][2]). This regulatory section also defines $10^{-6}$ as the "point of departure for determining remediation goals for alternatives when ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants...or...pathways of exposure".

For non-carcinogens (systemic toxicants), the EPA defines acceptable exposures as those to which the human population, including sensitive subgroups, may be exposed without adverse effects during a lifetime or part of a lifetime, incorporating a safety margin (40 CFR300.430 [E][2][i][A][1]). This acceptable exposure level is best approximated by a hazard index of unity (1.0). If the hazard index is less than unity, adverse effects would not be expected, while a hazard index greater than unity suggests that such an exposure may result in adverse effects.

It was decided that a cancer risk of $10^{-5}$ would be used as a preliminary screening tool for contaminants for the purposes of this FS. This decision was based on the fact that the HHRA risk estimates for Sites 1 and 2 are within the $10^{-4}$ to $10^{-6}$ range considered acceptable under current EPA Superfund policy. EPA's Acceptable Exposure Policy range and this risk level falls in the middle of the allowable range. Furthermore, even if all of the risk drivers were present at the PRG concentrations, the estimated total cancer risks would be less than $10^{-4}$.

## 2.3 Determination of Extent of Contaminated Media

The following section details the proposed cleanup goal selection process for each medium of concern, as the nature of the ARARs, TBCs, and risk values is medium-specific. Volumes and/or areas of contamination are then determined for each medium in which proposed cleanup goals were developed.

### 2.3.1 Groundwater

Since 1994 data are available for all wells and are presumably more representative of current conditions, the 1991 groundwater data were not considered in this FS.

The Potential groundwater exposure pathways developed by the HHRA for carcinogens for both sites include residential exposure to groundwater via dermal absorption, ingestion, and vapor inhalation. The potential groundwater exposure pathways developed by the HHRA for non-carcinogens include residential exposure to groundwater via dermal absorption, ingestion, and vapor inhalation for Site 1, and residential exposure to groundwater via dermal absorption and ingestion for Site 2.

The overall RAOs for groundwater for both sites are to prevent residential receptors from potential direct contact, ingestion, and inhalation of groundwater posing excess adverse human health risks and to attain contaminant concentrations within the groundwater that comply with ARARS.

#### 2.3.1.1 Selection of Groundwater Clean-up Goals ARARs

Preliminary remediation goals (PRGs) for groundwater are screened in Tables 2-1 and 2-2. The screening takes into account ARARs first, then both cancer and non-cancer human health risks. For purposes of developing PRGs, the cancer risk was set at $1 \times 10^{-5}$ and the HI was set to 1 for noncarcinogenic risks. In some instances, using 1 as the target HI for individual chemicals leads to a total HI for a specific target organ that is slightly greater than 1. However, given the conservative nature of the toxicity values and the considerable uncertainty associated with the risk estimates, these do not indicate a significant health concern. The overall human health risk associated with the selected PRGs is also shown in these tables.

The federal Safe Drinking Water Act (SDWA) 42 USC 300(f) *et seq.*, 40 CFR 141.175 protects public health by establishing primary drinking water standards for public and community water supplies and has been identified as an ARARs for Sites 1 and 2.

The primary drinking water standards address toxicity and are called Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs). MCLs are promulgated and enforceable standards that reflect maximum permissible levels of groundwater contaminants delivered to users of public water systems. MCLGs are non-enforceable standards that are protective to adverse human health effects and allow an adequate margin of safety. According to the NCP, MCLs or non-zero MCLGs are generally relevant and appropriate chemical-specific requirements also defines $10^{-6}$ as the "point of departure for determining remediation goals for alternatives when ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants...or...pathways of exposure".

For non-carcinogens (systemic toxicants), the EPA defines acceptable exposures as those to which the human population, including sensitive subgroups, may be exposed without adverse effects during a lifetime or part of a lifetime, incorporating a safety margin (40 CFR300.430 [E][2][i][A][1]). This acceptable exposure level is best approximated by a hazard index of unity (1.0). If the hazard index is less than unity, adverse effects would not be expected, while a hazard index greater than unity suggests that such an exposure may result in adverse effects.

It was decided that a cancer risk of $10^{-5}$ would be used as a preliminary screening tool for contaminants for the purposes of this FS. This decision was based on the fact that the HHRA risk estimates for Sites 1 and 2 are within the $10^{-4}$ to $10^{-6}$ range considered acceptable under current EPA Superfund policy. EPA's Acceptable Exposure Policy range and this risk level falls in the middle of the allowable range. Furthermore, even if all of the risk drivers were present at the PRG concentrations, the estimated total cancer risks would be less than $10^{-4}$.

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### 2.3.1 Groundwater

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The Potential groundwater exposure pathways developed by the HHRA for carcinogens for both sites include residential exposure to groundwater via dermal absorption, ingestion, and vapor inhalation. The potential groundwater exposure pathways developed by the HHRA for non-carcinogens include residential exposure to groundwater via dermal absorption, ingestion, and vapor inhalation for Site 1, and residential exposure to groundwater via dermal absorption and ingestion for Site 2.

The overall RAOs for groundwater for both sites are to prevent residential receptors from potential direct contact, ingestion, and inhalation of groundwater posing excess adverse human health risks and to attain contaminant concentrations within the groundwater that comply with ARARS.

#### 2.3.1.1 Selection of Groundwater Clean-up Goals ARARs

Preliminary remediation goals (PRGs) for groundwater are screened in Tables 2-1 and 2-2. The screening takes into account ARARs first, then both cancer and non-cancer human health risks. For purposes of developing PRGs, the cancer risk was set at $1 \times 10^{-5}$ and the HI was set to 1 for noncarcinogenic risks. In some instances, using 1 as the target HI for individual chemicals leads to a total HI for a specific target organ that is slightly greater than 1. However, given the conservative nature of the toxicity values and the considerable uncertainty associated with the risk estimates, these do not indicate a significant health concern. The overall human health risk associated with the selected PRGs is also shown in these tables.

The federal Safe Drinking Water Act (SDWA) 42 USC 300(f) *et seq.*, 40 CFR 141.175 protects public health by establishing primary drinking water standards for public and community water supplies and has been identified as an ARARs for Sites 1 and 2.

The primary drinking water standards address toxicity and are called Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs). MCLs are promulgated and enforceable standards that reflect maximum permissible levels of groundwater contaminants delivered to users of public water systems. MCLGs are non-enforceable standards that are protective to adverse human health effects and allow an adequate margin of safety. According to the NCP, MCLs or non-zero MCLGs are generally relevant and appropriate chemical-specific requirements for groundwater that is a current or potential source of drinking water. These standards are presented in Tables 2-1 and 2-2.

### Risk Assessment

Site-specific human health risk values (contaminant concentrations that represent cancer risks in excess of $10^{-5}$ or a hazard index (HI) of 1.0) were developed for contaminants found for which cancer risks or hazard indices could be calculated. Information supporting the derivation of these values is presented in Appendix B. The site-specific risk based values are presented in Tables 2-1 and 2-2 (as risk-based PRGs and where there is no potential ARAR or where the risk-based concentration is lower than the ARAR).

### Background

Background groundwater concentrations were also considered as screening criteria. These were calculated for inorganic compounds from the unfiltered concentrations in the two wells, 1-GW-1 and 2-GW-1, considered upgradient of Sites 1 and 2, respectively, over the ten sample rounds. These wells are considered representative of background levels of inorganics in groundwater at the NTC. The groundwater background sample locations are shown on Figures 2-1 and 2-2. The background concentration was calculated for each analyte as the average average plus two standard deviations. Because the resulting background values are lower than PRGs they were eliminated from consideration as cleanup goals and do not appear in Tables 2-1 and 2-2.

### Selection of Groundwater Clean-up Goals

The following logical basis was used to select the proposed clean-up goals presented in this table.

- The preliminary remediation goals are set at the non-zero MCLG.

- Where non-zero MCLGs do not exist or are not relevant and appropriate, MCLs are established as preliminary remediation goals, where they exist.

- Where neither the MCL nor the MCLG exist, the preliminary remediation goal is set to the site-specific human health risk values.

- Preliminary remediation goals are then compared to the maximum observed concentrations for each contaminant to determine which contaminants may require clean-up.

- As a final step, the contaminants identified for clean-up are reviewed to determine whether they are site-related or warrant remediation. Proposed cleanup goals, based on the preliminary screening values, are then set only for those contaminants that are determined to be site-related or that warrant cleanup.

Based on the cleanup goal screening process for groundwater, as presented in Tables 2-1 and 2-2, the following was concluded:

### Site 1

Three inorganics ( iron, manganese and antimony) as well as four volatile organic compounds (VOCs), (trichloroethene (TCE), vinyl chloride (VC), choloroform, and cholorobenzene) were detected above preliminary remediation goals at Site 1.

### VOCs

TCE was detected above its screening value of 5 $\mu$g/L in four sample locations, at concentrations ranging from 6 to 24 $\mu$g/L. Vinyl chloride was detected above its PRG value of 2 $\mu$g/L in only one well, 1-GW-9, in only 1 sampling round, at a concentration of 5 $\mu$g/L. Chloroform exceeded the PRG just once (4$\mu$g/l). Chlorobenzene was detected above PRGs in three wells (1-GW-3, 1-GW-5, and 1-GW-8).

### Inorganics

Iron and manganese were both detected above their respective PRGs values of 4,700 and 300 $\mu$g/L in eight wells. Iron concentrations ranged from 4,720 - 37,500 $\mu$g/L, while manganese concentrations ranged from 323 - 7,540 $\mu$g/L. Antimony was detected just once in well 1-GW-4.

### Site 2

Two inorganics, iron and manganese; two VOCs, 1,1,2,2-tetrachloroethane, and chloroform; and three carcinogenic PAHs were detected above preliminary remediation goals at Site 2.

### VOCs

1,1,2,2- tetrachloroethane was detected above its PRG value of 2 $\mu g/L$ in one well, 2-GW-12, in the 1994 sampling round, at concentrations ranging from 5 - 8 $\mu g/L$. Chloroform was found in two wells above the PRG (2-GW-4 and 2-GW-11), and only once in the first sampling round of 1994.

### PAHs

Three carcinogenic PAHs, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene, were detected above their respective PRGs in only one well, 2-GW-8, in 1994. Individual PAH concentrations ranged from 1 - 3 $\mu g/L$.

### Inorganics

Iron and manganese were both detected above their respective screening value of 4,700 and 300 $\mu g/L$ in six wells. Iron concentrations ranged from 3,590 - 79,200 $\mu g/L$, while manganese concentrations ranged from 714 - 5,500 $\mu g/L$.

Table 2-3 presents proposed cleanup goals based on the results of the value comparisons presented in Tables 2-1 and 2-2.

### 2.3.2 Sediment

Contaminated sediments at this site were determined to pose only a risk to ecological receptors. Based on the conceptual model developed in the Desktop ERA, the sediment exposure pathways included direct contact with, and ingestion of, sediment for benthos and fish; and ingestion of sediment and of fish and invertebrates by birds and mammals.

The overall RAOs for sediment for both sites are to prevent ecological receptors from potential direct contact with and the indirect ingestion of sediments posing excess adverse health risks; and to attain contaminant concentrations within the sediments conductive to aquatic organism survival.

#### 2.3.2.1 Selection of Sediment Preliminary Remediation Goals

**ARARs**

No chemical-specific ARARs were identified for sediments.

**TBCs**

TBCs identified for sediment were the EPA Region III Risk-Based Concentration values for fish (October 1998). The EPA Region III RBC fish values are presented in Tables 2-4 and 2-5.

**Risk Assessment**

Desktop Ecological risk values were developed for sediment contaminants found at each of the sites. In the case of the food chain analysis of the kingfisher and the racoon, the ecological risk value was calculated based on the HQs calculated in the Desktop Ecological Risk Assessment (ERA) in order to attain a concentration to compare to TBCs, background values, and maximum contaminant concentrations. Information supporting the calculation of these ecological risk values is presented in Appendix C. The Desktop ERA values are presented in Tables 2-4 and 2-5.

**Background**

Background sediment data collected in 1997 by EA Engineering, Inc. during the EBS sampling, and in 1991 by E&E for the RI, were used to calculate background (see Section 1.5.3). Background concentrations are included as screening criteria, for both organic and inorganic compounds. These background concentrations represent the average plus two standard deviations for each analyte. These sample locations are shown on Figures 2-3 and 2-4. This additional sediment background data is presented in Appendix A.

**Selection of Sediment Clean-up Goals**

The following logical basis was used to select the preliminary remediation goals presented in Tables 2-4 and 2-5.

- The preliminary screening value is set to the most stringent of the Desktop ERA values or the EPA Region III RBC fish values. It should be noted that the Desktop ERA concluded, that risk to benthos at Site 2 is unlikely; therefore; risks to benthos will not be further evaluated for Site 2 in this FS.

- The preliminary screening value selected by this process is then compared to the background values, where they exist. In the event the background level is greater than the preliminary screening value, the background value becomes the preliminary screening value. This is done to ensure that the preliminary screening values are not set below the background concentrations.

- Preliminary screening values are then compared to the maximum observed concentrations for each contaminant to determine which contaminants may require clean-up.

- As a final step, the contaminants identified for clean-up are reviewed to determine whether they are site-related warrant remediation. Proposed remediation goals, based on the preliminary screening values, are then set only for those contaminants that are determined to be site-related or that warrant cleanup.

Based on the remediation goal screening process for sediment at Sites 1 and 2, as presented in Tables 2-4 and 2-5, the following was concluded:

### Site 1

Several inorganics, two pesticides, and 13 PAHs were detected above preliminary screening criteria at Site 1.

### Pesticides

Alpha-chlordane and gamma-chlordane were detected in sample locations P1-SD-7 and P1-SD-18 above their screening value of 0.024 mg/kg. Concentration ranges were 0.033 - 0.28 and 0.053 - 0.41 mg/kg, respectively.

Based on the nature of the pesticide contamination and of the detections, it appears that the presence of pesticides in the creeks almost certainly reflects installation-wide pesticide application, rather than disposal practices at the landfill or of contaminant migration, particularly since these contaminants sorb strongly to organic matter and are therefore relatively immobile. Therefore, these pesticides will not be addressed further in this FS.

### PAHs

Of the 13 PAHs detected above screening values, seven (acenaphthylene, anthracene, benzo(g,h,i)perylene, fluoranthene, fluorene, phenanthrene, and pyrene) were detected in only one sample location, P1-SD-9, at concentrations between 13 and 120 mg/kg. The remaining six PAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene) were detected above their screening values in seven or more sample locations at concentrations ranging from 0.12 to 74 mg/kg. Benzo(a)anthracene was detected in the greatest number of sampling locations (15). The highest concentration of each of these remaining six PAHs was detected in sample location P1-SD-9.

### Inorganics

Chromium, copper, lead, and manganese were detected above their preliminary screening values of 9.04, 9.65, 24.0, and 602 mg/kg, respectively, in several sample locations. Concentration ranges were from 8.6 - 49.4, 11.5 - 52.3, 23.1 - 387, and 882 - 5,600 mg/kg, respectively. Aluminum, cadmium, mercury, nickel, and zinc were detected above their preliminary screening values of 5192, 1.0, 0.054, 19.2 and 82.8 mg/kg, respectively, in 7, 5, 5, 6 and 2 sample locations, respectively. Concentrations ranges were from 5320 - 9,680, 1.4 - 3.1, 0.11 - 1.1, 32.5 - 57.1, and 104 - 186 mg/kg, respectively.

### *Site 2*

Four inorganics, cadmium, chromium, lead, and manganese were the only contaminants detected above preliminary screening criteria at Site 2.

### Inorganics

Cadmium was detected above its screening value of 1.0 mg/kg in only one sample location, P2-SD-8, at a concentration of 1.3 mg/kg. Chromium, lead and manganese were each detected in sample location P2-SD-8D, only, above their respective screening values of 9.04, 24.0, and 602 mg/kg. Chromium was detected at a concentration of 9.1 mg/kg; lead at a concentration of 35.5 mg/kg; and manganese at a concentration of 719 mg/kg. Essentially, these four inorganic contaminants were found only in one of the duplicate samples from location, P2-SD-8.

Table 2-6 presents preliminary remediation goals based on the results of the value comparisons presented in Tables 2-4 and 2-5. Actual cleanup values, if cleanup is determined to be necessary as a result of the proposed risk-based monitoring, would be developed in the future.)

### 2.3.3 Surface Water

Based on the conceptual model developed in the Desktop ERA, the surface water exposure includes direct contact with water for benthos, fish, birds, and mammals.

The overall RAOs for surface water for both sites are to prevent risk to aquatic life, thereby preventing risks to fauna consuming aquatic life. However, because it is generally impractical to remediate surface water bodies, this medium will not be addressed directly in this FS, rather the source of the surface water contamination will be addressed.

## 2.4 General Response Actions

The purpose of this section is to develop General Response Actions (GRAs) for each medium of concern. GRAs are actions that may be taken to satisfy the RAOs for each of the two sites. GRAs may include, but are not limited to, treatment, containment, excavation, extraction, disposal, institutional controls, or a combination of these. Like RAOs, GRAs are medium-specific.

### 2.4.1 Groundwater

Based on cleanup goals determined in Section 2.3.1.1, groundwater at Site 1 is contaminated with volatile organics, namely TCE and vinyl chloride, and metals; and groundwater at Site 2 is contaminated with metals and PAHs.

The GRAs for groundwater at both sites that address pathways of direct contact, ingestion, and inhalation of these contaminants and that may reduce the exposure risk of residential receptors to contaminated groundwater include containment, collection, treatment, disposal, institutional controls, and no-action. Containment would prevent direct exposure of the contaminants to receptors and/or restrict or minimize the migration of the plume and its contaminants into adjacent sediment, groundwater, and surface water. Collection provides a means by which the contamination is physically collected from the aquifer. Treatment reduces the toxicity, mobility, or volume of contaminants and can include physical, chemical, thermal, and/or biological processes, and can be implemented either on or off site. Disposal or discharge is usually implemented following collection and treatment. Institutional controls (e.g., monitoring and access restrictions) would monitor site conditions and limit site access, thereby minimizing exposure to contaminants. Exercising a no-action alternative would leave groundwater in its current condition.

### 2.4.2 Sediment

Based on cleanup goals determined in Section 2.3.2.1, sediments at Site 1 are contaminated with metals and PAHs. At Site 2, sediments are only contaminated with metals.

The GRAs for sediment at both sites that address pathways of direct contact and ingestion of these contaminants and that may reduce the exposure risk of environmental receptors to contaminated sediment include containment, collection, treatment, disposal, institutional controls, and no-action.

Containment would prevent direct exposure of the contaminants to receptors and/or restrict or minimize the migration contaminants into adjacent sediment and surface water. Collection provides a means by which the contamination is physically collected. Treatment reduces the toxicity, mobility, or volume of contaminants and can include physical, chemical, thermal, and/or biological processes, and can be implemented either on or off site. Disposal is usually implemented following collection and treatment. Institutional controls (e.g., monitoring and access restrictions) would monitor site conditions and limit site access, thereby minimizing exposure to contaminants. Exercising a no-action alternative would leave sediment in its current condition.

## 2.5 Contaminated Media of Concern

### 2.5.1 Site 1

#### 2.5.1.1 Groundwater

Groundwater at Site 1 was determined to be contaminated with VOCs, and metals. Using the cleanup goals developed in Section 2.3.1.1 and the RI analytical data, groundwater samples with concentrations exceeding site cleanup goals were identified. Based on these data, Figure 2-1 shows the area of contaminated groundwater at Site 1, as well as contaminant concentrations exceeding cleanup goals. The total contaminated groundwater plume volume is estimated to be 80 million gallons (see Appendix D). This estimate is based on groundwater cleanup goals and information concerning the extent of contamination presented in the RI. It should be noted here that Site 1 was closed under the IRM conducted in 1994/1995.

#### 2.5.1.2 Sediment

Sediments at Site 1 were determined to be contaminated with metals and PAHs. Using the preliminary remediation goals determined in Section 2.3.2.1 and the RI analytical data, sediment samples with concentrations exceeding goals were identified. Based on these data, Figure 2-5 shows the area of contaminated sediments, as well as contaminant concentrations exceeding preliminary cleanup goals. The total volume of contaminated sediments at Site 1 is estimated to be 230 cubic yards (see Appendix D). This estimate is based on an average stream/ditch width of four feet and an estimated sediment depth of six inches.

### 2.5.2 Site 2

#### 2.5.2.1 Groundwater

Groundwater at Site 2 was determined to be contaminated with VOCs, PAHs, and metals. Using the cleanup goals determined in Section 2.3.1.1 and the RI analytical data, groundwater samples with concentrations exceeding cleanup goals were identified. Based on these data, Figure 2-2 shows the area of contaminated groundwater at Site 2, as well as contaminant concentrations exceeding cleanup goals. The total contaminated groundwater plume volume is estimated to be 8 million gallons (see Appendix D). This estimate is based on groundwater cleanup goals and information concerning the extent of contamination presented in the RI.

#### 2.5.2.2 Sediment

Sediments at Site 2 were determined to be slightly contaminated with metals. Using the preliminary remediation goals determined in Section 2.3.2.1 and the RI analytical data, sediment samples with concentrations exceeding preliminary cleanup goals were identified. Based on these data, Figure 2-6 shows the area of contaminated sediments, as well as contaminant concentrations exceeding goals. The total volume of contaminated sediments at Site 2 is estimated to be 10 cubic yards (see Appendix D). This estimate is based on an average stream/creek width of four feet and an estimated sediment depth of six inches.

**Table 2-1**

## CLEANUP GOAL SCREENING PROCESS FOR GROUNDWATER SITE 1

| Chemical | Potential ARAR[a] (µg/L) | PRG (µg/L) | Maximum (µg/L) | Cancer Risk at PRG | Child HI at PRG | Adult HI at PRG | Target organs |
|---|---|---|---|---|---|---|---|
| Trichlorethene | 5 | 5[b] | 24 | 1E-06 | 0.06 | 0.03 | -- |
| Viny chloride | 2 | 2[b] | 2.8 | 6E-05 | -- | -- | -- |
| Chloroform | 80 | 2[c] | 4 | 3E-06 | 0.01 | 0.9 | Respiratory system |
| Iron | -- | 4,700[d] | 37,350 | -- | 1.0 | 0.4 | Brain, Liver, Gastrointestinal system |
| Manganese | -- | 300[d] | 6,970 | -- | 1.0 | 0.4 | Central nervous system |
| Chlorobenzene | 100 | 100[b] | 355 | -- | 0.5 | 0.5 | Liver |
| Antimony | 6 | 6[b] | 32.4 | -- | 1.0 | 0.4 | Brain, Liver, Cardiovascular system |
| HI subtotal | -- | -- | -- | -- | 0.01 | 0.9 | Respiratory system |
| HI subtotal | -- | -- | -- | -- | 2.0 | 0.9 | Brain |
| HI subtotal | -- | -- | -- | -- | 2.5 | 1.4 | Liver |
| HI subtotal | -- | -- | -- | -- | 1.0 | 0.4 | Gastrointestinal system |
| Hi subtotal | -- | -- | -- | -- | 1.0 | 0.4 | Central nervous system |
| | | | | | 1.0 | 0.4 | Cardiovascular system |
| Total cancer risk | -- | -- | -- | 7E-05 | -- | -- | |

a Concentration shown is the lower of MCL or non-zero MCLG for drinking water.
b ARAR.
c Concentration shown is risk-based to target cancer risk of 1E-05.
d Concentration shown is risk-based to target noncancer HI of 1.0.

## Table 2-2

## CLEANUP GOAL SCREENING PROCESS FOR GROUNDWATER
## SITE 2

| Chemical | Potential ARAR[a] ($\mu$g/L) | PRG ($\mu$g/L) | Maximum ($\mu$g/L) | Cancer Risk at PRG | Child HI at PRG | Adult HI at PRG | Target organs |
|---|---|---|---|---|---|---|---|
| 1,1,2,2-Tetrachlorethane | -- | 2[b] | 8 | 1E-05 | 0.002 | 0.001 | |
| Benzo(a)anthracene | -- | 1.1[b] | 1 | 1E-05 | -- | -- | |
| Benzo(a)pyrene | 0.2 | 0.12[b] | 2 | 1E-05 | -- | -- | |
| Benzo(b)fluoranthene | -- | 1.2[b] | 3 | 1E-05 | -- | -- | |
| Benzo(k)fluoranthene | -- | 11[b] | 2 | 1E-05 | -- | -- | |
| Chrysene | -- | 120[b] | 2 | 1E-05 | -- | -- | |
| Indeno(1,2,3-cd)pyrene | -- | 1.2[b] | 2 | 1E-05 | -- | -- | |
| Chloroform | 80 | 2[b] | 16 | 3E-06 | 0.01 | 0.9 | Respiratory system |
| Iron | -- | 4700[c] | 79,200 | -- | 1.0 | 0.4 | Brain, Liver, Gastrointestinal system |
| Manganese | -- | 300[c] | 5500 | -- | 1.0 | 0.4 | Central nervous system |
| HI subtotal | -- | -- | -- | -- | 0.01 | 0.9 | Respiratory system |
| HI subtotal | -- | -- | -- | -- | 1.0 | 0.4 | Brain |
| HI subtotal | -- | -- | -- | -- | 1.0 | 0.4 | Liver |
| HI subtotal | -- | -- | -- | -- | 1.0 | 0.4 | Gastrointestinal system |
| HI subtotal | -- | -- | -- | -- | 1.0 | 0.4 | Central nervous system |
| Total cancer risk | -- | -- | -- | 7E-05 | -- | -- | |

a Concentration shown is the lower of MCL or non-zero MCLG for drinking water.
b Concentration show is risk-based to target cancer risk of 1E-05.
c Concentration shown is risk-based to target noncancer HI of 1.0.

**Table 2-3**

**GROUNDWATER PRELIMINARY REMEDIATION GOALS**
**($\mu$g/L)**

| Contaminant | Cleanup Goal |
|---|---|
| **Site 1** | |
| Chloroform | 2 |
| Chlorobenzene | 100 |
| TCE | 5 |
| Vinyl Chloride | 2 |
| Antimony | 6 |
| Iron | 4,700 |
| Manganese | 300 |
| **Site 2** | |
| 1,1,2,2-PCA | 2 |
| Chloroform | 2 |
| Benzo(a)anthracene | 1.1 |
| Benzo(a)pyrene | 0.12 |
| Benzo(b)fluoranthene | 1.2 |
| Benzo(k)fluoranthene | 11 |
| Chrysene | 120 |
| Indeno(1,2,3-cd)pyrene | 1.2 |
| Iron | 4,700 |
| Manganese | 300 |

Table 2-4

**PRELIMINARY REMEDIATION GOAL SCREENING PROCESS FOR SEDIMENT**
**SITE 1**
***(concentrations in mg/kg)***

| Contaminant | TBCs<br>EPA Region III RBCs - Fish | Desktop ERA Risk Values | Background | Preliminary Screening Value | Maximum Concentration | Preliminary Remediation Goal |
|---|---|---|---|---|---|---|
| Acenaphthylene | ------ | 5.4[a,b] | 0.440 | 5.4 | 15 | 5.4 |
| Anthracene | 410 | 5.2[a,b] | 0.532 | 5.2 | 27 | 5.2 |
| Benzo(a)anthracene | 0.0043 | 5.3[a,b] | 0.481 | 0.481 | 47 | 0.481 |
| Benzo(a)pyrene | 0.00043 | 5.2[a,b] | 0.468 | 0.468 | 54 | 0.468 |
| Benzo(b)fluoranthene | 0.0043 | 5.2[a,b] | 0.509 | 0.509 | 74 | 0.509 |
| Benzo(g,h,i)pyrene | ----- | 5.1[a,b] | 0.483 | 5.1 | 36 | 5.1 |
| Benzo(k)fluoranthene | 0.043 | 5.1[a,b] | 0.488 | 0.488 | 35 | 0.488 |
| Chrysene | 0.43 | 5.2[a,b] | 0.468 | 0.468 | 55 | 0.468 |
| Fluoranthene | 54 | 5.0[a,b] | 0.454 | 5.0 | 120 | 5.0 |
| Fluorene | 54 | 5.0[a,b] | 0.532 | 5.0 | 13 | 5.0 |
| Indeno(1,2,3-cd)pyrene | 0.0043 | 5.1[a,b] | 0.491 | 0.491 | 38 | 0.491 |
| Phenanthrene | ----- | 5.0[a,b] | 0.484 | 5.0 | 120 | 5.0 |
| Pyrene | 41 | 5.2[a,b] | 0.457 | 5.2 | 89 | 5.2 |
| Total PAHs | ----- | 4.0[c,d] | ----- | 4.0 | [e] | ----- |
| Alpha-chlordane | 0.009[f] | 0.04[a,h] | 0.028 | 0.028 | 0.28[k] | ----- |
| Gamma-chlordane | 0.009[f] | 0.04[a,h] | 0.028 | 0.028 | 0.41[k] | ----- |
| Total chlordane | 0.009 | 0.0005[c,d] | 0.028 | 0.028 | [e] | ----- |

**Table 2-4**

**PRELIMINARY REMEDIATION GOAL SCREENING PROCESS FOR SEDIMENT**
**SITE 1**
**(concentrations in mg/kg)**

| Contaminant | TBCs: EPA Region III RBCs - Fish | Desktop ERA Risk Values | Background | Preliminary Screening Value | Maximum Concentration | Preliminary Remediation Goal |
|---|---|---|---|---|---|---|
| Total DDT | 0.009 | 0.003[c,d] | 0.036 | 0.036 | [e] | ----- |
| Aluminum | 1,400 | 22[a,b] | 5192 | 5192 | 9,680 | 5192 |
| Cadmium | 1.4[l] | 0.6[a,h] | 1.0 | 1.0 | 3.1 | 1.0 |
| Chromium (total) | 4.1[b] | 0.68[a,b] | 9.04 | 9.04 | 49 | 9.04 |
| Copper | 54 | 0.44[a,h] | 9.65 | 9.65 | 48 | 9.65 |
| Lead | ----- | 0.56[a,h] | 24.0 | 24.0 | 387 | 24.0 |
| Manganese | 190[l] | 5.2[a,b] | 602 | 602 | 5,600 | 602 |
| Mercury | 0.14[l] | 0.023[a,h] | 0.054 | 0.054 | 1.1 | 0.054 |
| Nickel | 27 | 18[d,i] | 19.2 | 19.2 | 57.1 | 19.2 |
| Zinc | 410 | 26[a,h] | 82.8 | 82.8 | 186 | 82.8 |

a Value based on III of 1.
b Value based on risk to racoon.
c ER-L value (Long and Morgan 1990).
d Value based on risk to benthos.
f Based on value for chlordane.
g Based on value for chlordane.
h Value based on risk to kingfisher.
i TEL values (Smith, et. al. 1996).
j Cadmium data from EBA samples unusable. Not detected in RI background samples. Value equal to the quantitation limit of RI samples.
k Not a site- related contaminate.
l Fish tissue value.

Key:
----- = Value has not been established for contaminant.

Table 2-5

## PRELIMINARY REMEDIATION GOAL SCREENING PROCESS FOR SEDIMENT SITE 2 (concentrations in mg/kg)

| Contaminant | TBCs: EPA Region III RBCs - Fish | Desktop ERA Risk Values | Background | Preliminary Screening Value | Maximum Concentration | Preliminary Remediation Goal |
|---|---|---|---|---|---|---|
| 4,4'-DDE | 0.009 | 0.2[b,c] | 0.015 | 0.015 | 0.013 | ----- |
| Aluminum | 1,400 | 155[b,c] | 5193 | 5193 | 3,710 | ----- |
| Cadmium | 1.4[g] | 0.6[b,c] | 1.0[f] | 1.0 | 1.3 | 1.0 |
| Chromium (total) | 4.1[a] | 0.68[b,d] | 9.04 | 9.04 | 9.1 | 9.04 |
| Copper | 5.4 | 0.44[b,c] | 9.65 | 11.25 | 8.8 | ----- |
| Lead | ----- | 0.56[b,c] | 24.0 | 24.0 | 35.5 | 24.0 |
| Manganese | 190[g] | 5.2[b,e] | 602 | 602 | 719 | 602 |

[a] Based on value for chromium VI
[b] Value based on HI of 1
[c] Value based on risk to Kingfisher
[d] Value based on risk to racoon
[e] ER-L values (Long and Morgan 1990)
[f] Cadmium data form EBA samples were unusable. Not detected in RI background samples. Value equal to the quantitation of RI samples.
[g] Fish tissue value.

Key:

----- = Value has not been established for contaminant.

**Table 2-6**

**SEDIMENT PRELIMINARY REMEDIATION GOALS (mg/kg)**

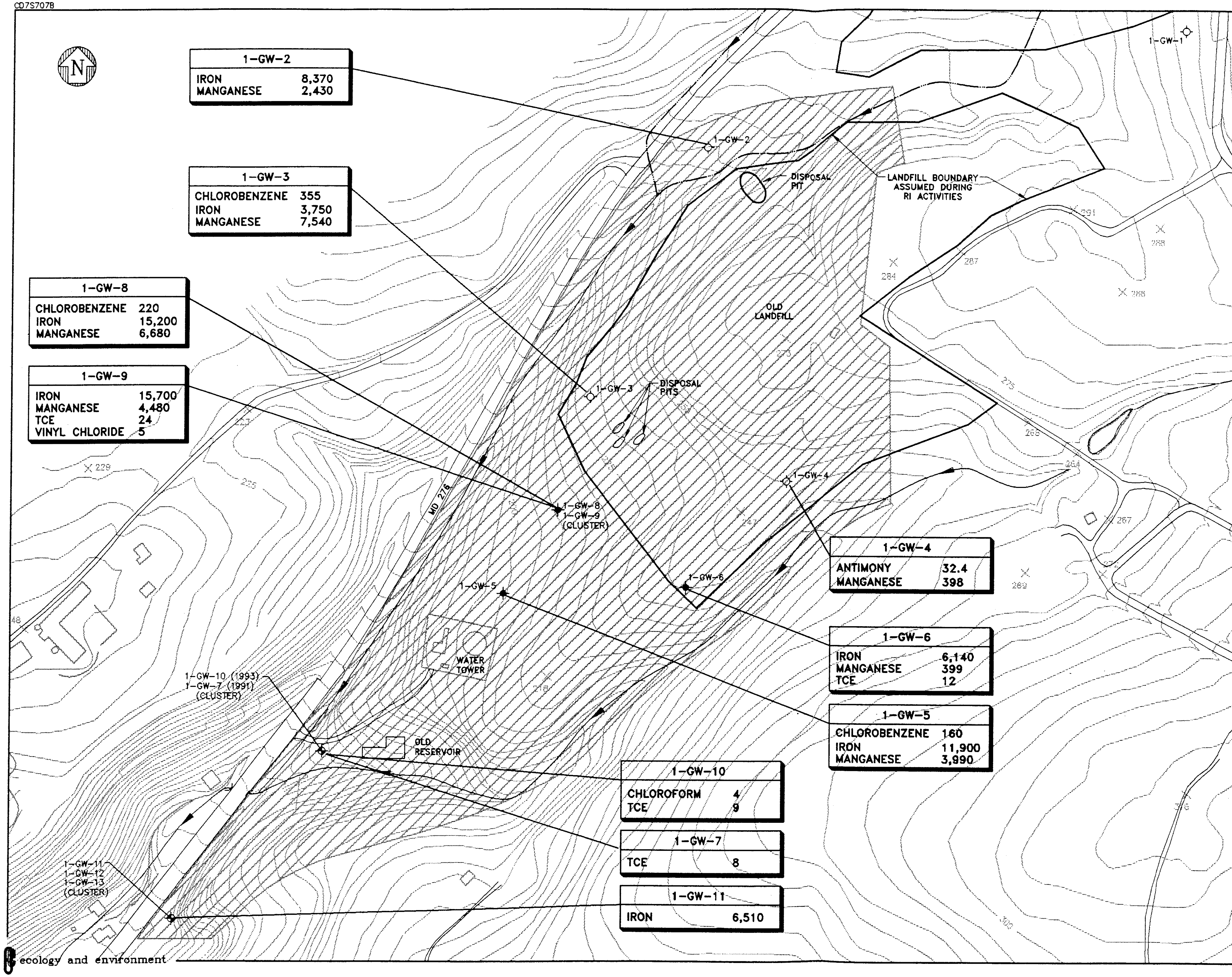
| Contaminant | Cleanup Goal |
|---|---|
| **Site 1** | |
| Acenaphtylene | 5.4 |
| Anthracene | 5.2 |
| Benzo(a)anthracene | 0.481 |
| Benzo(a)pyrene | 0.468 |
| Benzo(b)fluoranthene | 0.509 |
| Benzo(g,h,i)perylene | 5.1 |
| Benzo(k)fluoranthene | 0.488 |
| Chrysene | 0.468 |
| Fluoranthene | 5.0 |
| Fluorene | 5.0 |
| Indeno(1,2,3-cd)pyrene | 0.491 |
| Phenanthrene | 5.0 |
| Pyrene | 5.2 |
| Aluminum | 5,192 |
| Cadmium | 1.0 |
| Chromium (Total) | 9.04 |
| Copper | 9.65 |
| Lead | 24.0 |
| Manganese | 602 |
| Mercury | 0.054 |
| Nickel | 19.2 |
| Zinc | 82.8 |

## Table 2-6

## SEDIMENT PRELIMINARY REMEDIATION GOALS
**(mg/kg)**

| Contaminant | Cleanup Goal |
|---|---|
| **Site 2** | |
| Cadmium | 1.0 |
| Chromium (Total) | 9.04 |
| Lead | 24.0 |
| Manganese | 602 |

CD7S707B



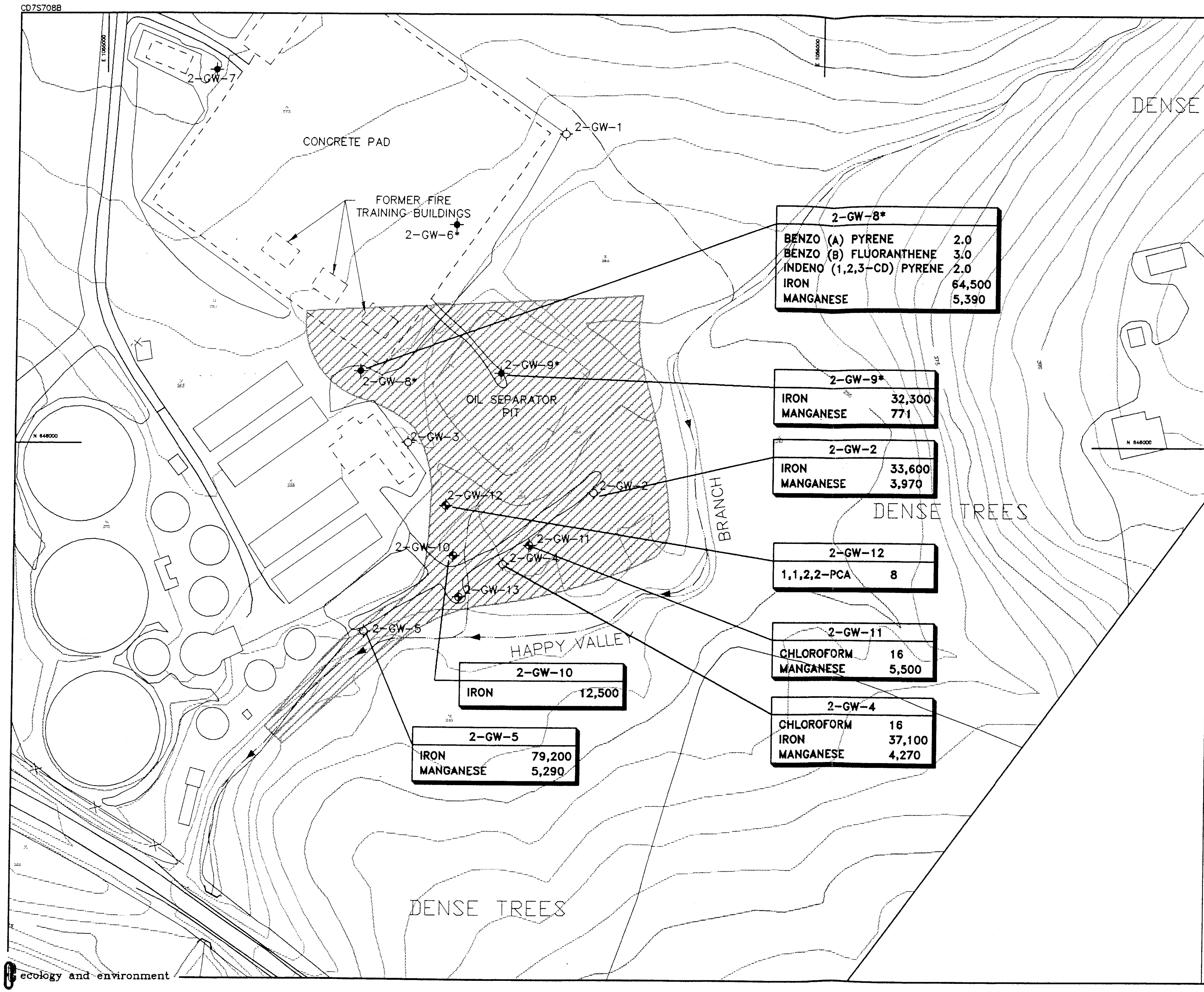

| GROUNDWATER CLEANUP GOALS | |
|---|---|
| CONTAMINANT | CLEANUP GOAL |
| CHLOROFORM | 2 |
| CHLOROBENZENE | 100 |
| ANTIMONY | 6 |
| TCE | 5 |
| VINYL CHLORIDE | 2 |
| IRON | 4,700 |
| MANGANESE | 300 |

NOTES:
1. ANALYTICAL RESULTS ARE IN $\mu g/L$.
2. CONCENTRATIONS BASED ON 1994 DATA

Figure 2-1 CONTAMINANTS IN GROUNDWATER EXCEEDING CLEANUP GOALS SITE 1 - OLD LANDFILL NAVAL TRAINING CENTER BAINBRIDGE



BUFF plotted: 09/27/99 MEH




| GROUNDWATER CLEANUP GOALS | |
|---|---|
| CONTAMINANT | CLEANUP GOAL |
| 1,1,2,2-PCA | 2 |
| CHLOROFORM | 2 |
| BENZO(a)ANTHRACENE | 1.1 |
| BENZO(a)PYRENE | 0.12 |
| BENZO(b)FLUORANTHENE | 1.2 |
| BENZO(k)FLUORANTHENE | 11 |
| CHRYSENE | 120 |
| INDENO(1,2,3-CD)PYRENE | 1.2 |
| IRON | 4,700 |
| MANGANESE | 300 |

NOTES:

1. ANALYTICAL RESULTS ARE IN $\mu g/L$.
2. CONCENTRATIONS BASED ON 1994 DATA

LEGEND

- WELLS INSTALLED DURING SI (1988)
- WELLS INSTALLED DURING RI (1991)
- WELLS INSTALLED DURING RI (1993)
- 2-GW-2 MONITORING WELL
- 2-GW-6* ABANDONED MONITORING WELL
- 225 TOPOGRAPHIC CONTOUR
- REMOVED STRUCTURE
- ESTIMATED AREA OF CONTAMINATION

N

SCALE IN FEET

0 150 300 450

Figure 2-2 CONTAMINANTS IN GROUNDWATER EXCEEDING CLEANUP GOALS
SITE 2 - FIRE TRAINING AREA
NAVAL TRAINING CENTER - BAINBRIDGE

BUFF PLOT: 09/23/99 MEH

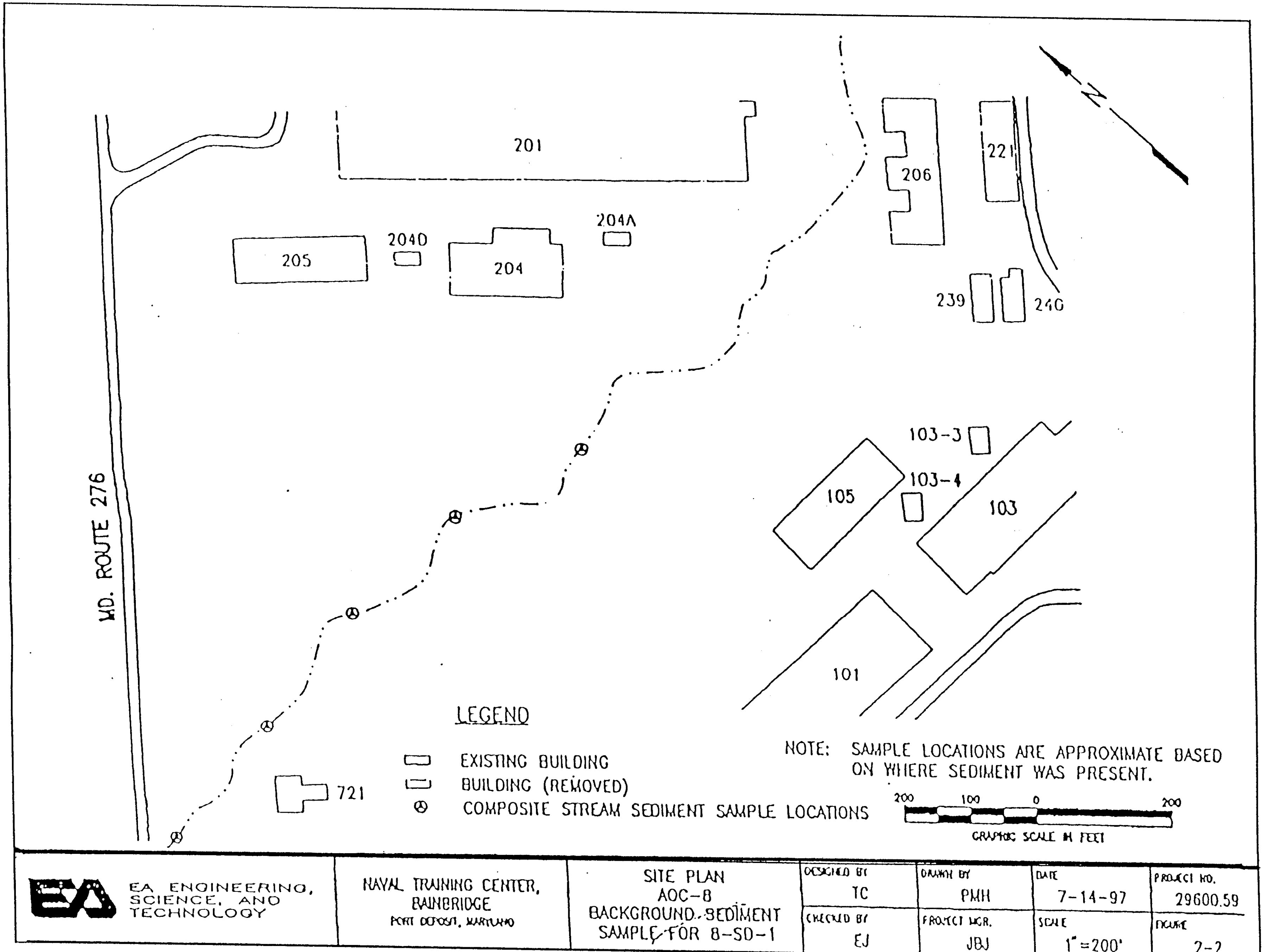



Figure 2-3 **BAINBRIDGE NTC**
**SEDIMENT BACKGROUND SAMPLE 8-SD-1**

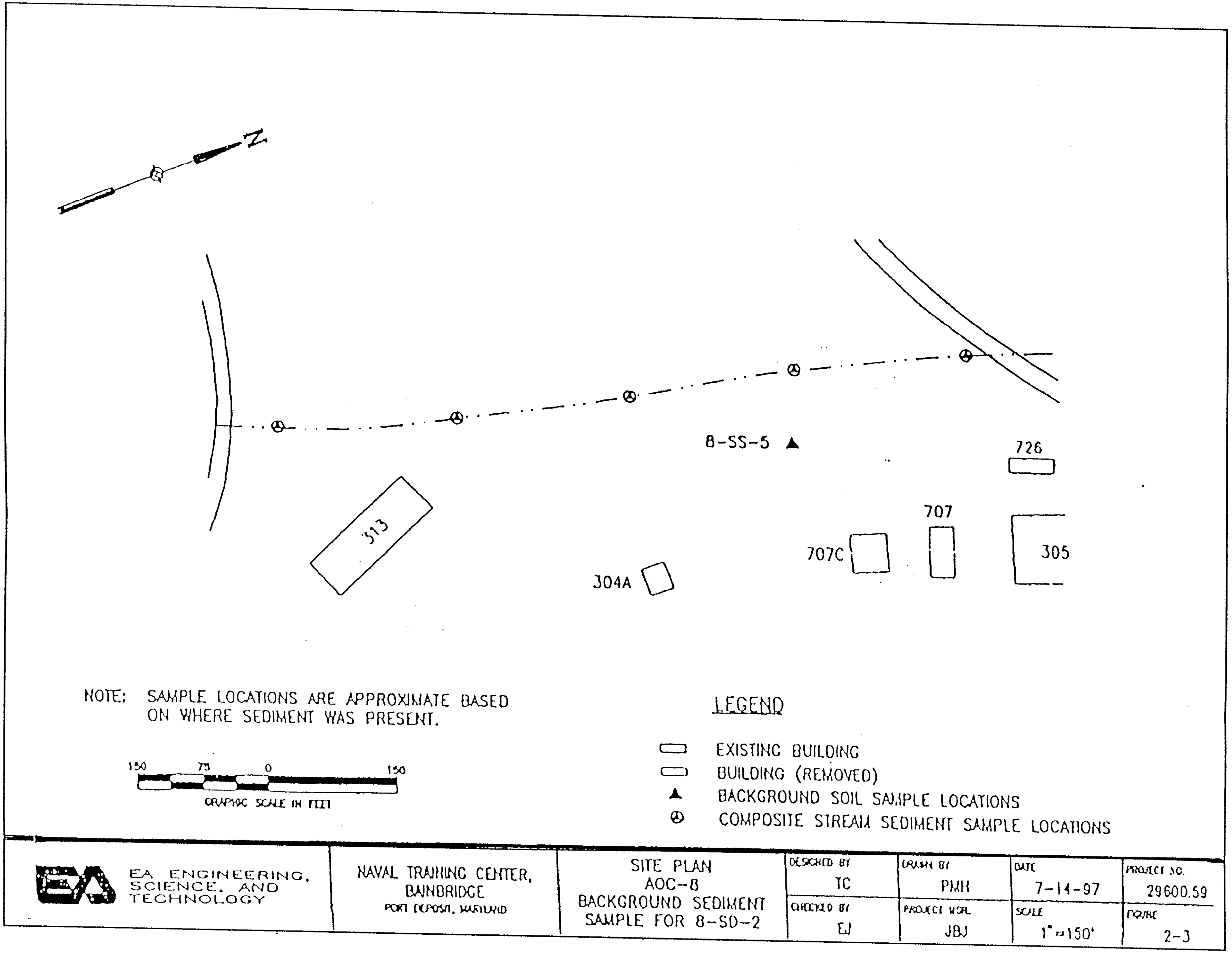



Figure 2-4 **BAINBRIDGE NTC**
**SEDIMENT BACKGROUND SAMPLE 8-SD-2**

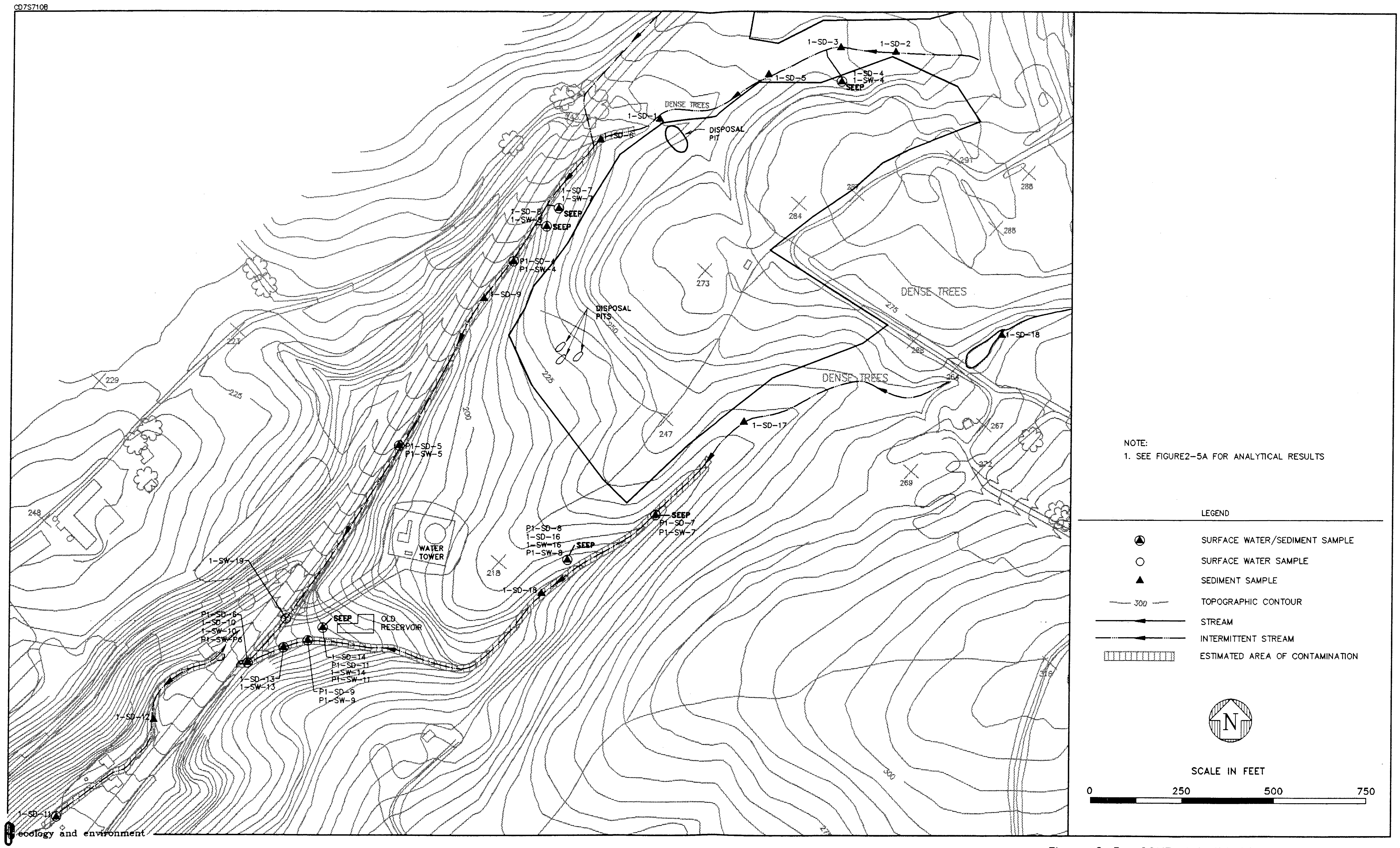



Figure 2-5 CONTAMINANTS IN SEDIMENT EXCEEDING PRELIMINARY CLEANUP GOALS
SITE 1 – OLD LANDFILL AREA
NAVAL TRAINING CENTER – BAINBRIDGE

CD7S711B

| P1-SD-4 | |
|---|---|
| ALUMINUM | 5,320 |
| CADMIUM | 2.1 |
| CHROMIUM | 18.1 |
| COPPER | 13.1 |
| LEAD | 88.7 |
| MANGANESE | 1,320 |

| P1-SD-5 | |
|---|---|
| BENZO (a) ANTHRACENE | 1.8 |
| BENZO (a) PYRENE | 1.8 |
| BENZO (b) FLUORANTHENE | 2.2 |
| BENZO (k) FLUORANTHENE | 1.5 |
| CHRYSENE | 1.8 |
| INDENO (1,2,3-cd) PYRENE | 1.1 |
| CADMIUM | 1.5 |
| CHROMIUM | 37 |
| LEAD | 102 |
| MANGANESE | 1720 |

| P1-SD-6 | |
|---|---|
| CADMIUM | 3.1 |
| CHROMIUM | 9 |
| COPPER | 16 |
| LEAD | 24.4 |
| MANGANESE | 1,190 |
| MERCURY | 0.12 |
| NICKEL | 28.8 |

| P1-SD-7 | |
|---|---|
| BENZO (a) ANTHRACENE | 1.1 |
| BENZO (a) PYRENE | 1.2 |
| BENZO (b) FLUORANTHENE | 1.5 |
| BENZO (k) FLUORANTHENE | 0.69 |
| CHRYSENE | 1.1 |
| INDENO (1,2,3-cd) PYRENE | 0.81 |
| ALUMINUM | 5,450 |
| CHROMIUM | 14.4 |
| COPPER | 25 |
| MERCURY | 0.19 |

| P1-SD-8 | |
|---|---|
| CADMIUM | 1.4 |
| MERCURY | 0.11 |

| P1-SD-9 | |
|---|---|
| ACENAPHTHYLENE | 15 |
| ANTHRACENE | 27 |
| BENZO (a) ANTHRACENE | 47 |
| BENZO (a) PYRENE | 54 |
| BENZO (b) FLUORANTHENE | 74 |
| BENZO (g,h,I) PERYLENE | 36 |
| BENZO (k) FLUORANTHENE | 35 |
| CHRYSENE | 55 |
| FLUORANTHENE | 120 |
| FLUORENE | 13 |
| INDENO (1,2,3-cd) PYRENE | 38 |
| PHEANTHRENE | 120 |
| PYRENE | 89 |
| CHROMIUM | 11.3 |
| MERCURY | 0.11 |
| NICKEL | 32.5 |

| P1-SD-11 | |
|---|---|
| ALUMINUM | 9,680 |
| CADMIUM | 2.2 |
| CHROMIUM | 49.4 |
| COPPER | 25 |
| LEAD | 387 |
| MANGANESE | 5,600 |
| ZINC | 186 |

| 1-SD-6 | |
|---|---|
| BENZO (a) ANTHRACENE | 1.2 |
| BENZO (a) PYRENE | 1.2 |
| BENZO (b) FLUORANTHENE | 1.5 |
| CHRYSENE | 1.1 |
| INDENO (1,2,3-cd) PYRENE | 0.76 |
| ALUMINUM | 5,980 |
| CHROMIUM | 13.9 |
| COPPER | 26.7 |
| LEAD | 56.8 |
| NICKEL | 24.9 |

| 1-SD-7 | |
|---|---|
| CHROMIUM | 12.9 |
| COPPER | 52.3 |
| MANGANESE | 3,210 |
| NICKEL | 41.5 |

| 1-SD-8 | |
|---|---|
| COPPER | 15.4 |
| MANGANESE | 1,510 |

| 1-SD-9 | |
|---|---|
| LEAD | 24 |
| MAGANESE | 1,170 |

| 1-SD-10 | |
|---|---|
| MANGANESE | 892 |

| 1-SD-11 | |
|---|---|
| COPPER | 26.6 |
| NICKEL | 33.1 |

| 1-SD-12 | |
|---|---|
| COPPER | 14.5 |
| LEAD | 25.7 |
| MANGANESE | 903 |

| 1-SD-13 | |
|---|---|
| BENZO (a) ANTHRACENE | 0.56 |
| BENZO (b) FLUORANTHENE | 0.55 |
| CHRYSENE | 0.50 |
| COPPER | 11.5 |

| 1-SD-14 | |
|---|---|
| COPPER | 19.6 |
| LEAD | 47.9 |
| ZINC | 87.5 |

| 1-SD-16 | |
|---|---|
| BENZO (a) ANTHRACENE | 0.75 |
| BENZO (a) PYRENE | 0.62 |
| BENZO (b) FLUORANTHENE | 0.88 |
| CHRYSENE | 0.79 |
| COPPER | 13.3 |

| 1-SD-18 | |
|---|---|
| ALUMINUM | 5,650 |
| CHROMIUM | 17.4 |
| COPPER | 18.1 |
| LEAD | 95.2 |

**PRELIMINARY SEDIMENT CLEANUP GOALS**

| CONTAMINANT | CLEANUP GOAL |
|---|---|
| ACENAPHTHYLENE | 5.4 |
| ANTHRACENE | 5.2 |
| BENZO(a)ANTHRACENE | 0.481 |
| BENZO(a)PYRENE | 0.468 |
| BENZO(b)FLUORANTHENE | 0.509 |
| BENZO(g,h,I)PERYLENE | 5.1 |
| BENZO(k)FLUORANTHENE | 0.488 |
| CHRYSENE | 0.468 |
| FLUORANTHENE | 5.0 |
| FLUORENE | 5.0 |
| INDENO(1,2,3-CD)PYRENE | 0.491 |
| PHENANTHRENE | 5.0 |
| PYRENE | 5.2 |
| ALUMINUM | 5,192 |
| CADMIUM | 1.0 |
| CHROMIUM (TOTAL) | 9.04 |
| COPPER | 9.65 |
| LEAD | 24.0 |
| MANGANESE | 602 |
| MERCURY | 0.054 |
| NICKEL | 19.2 |
| ZINC | 82.8 |

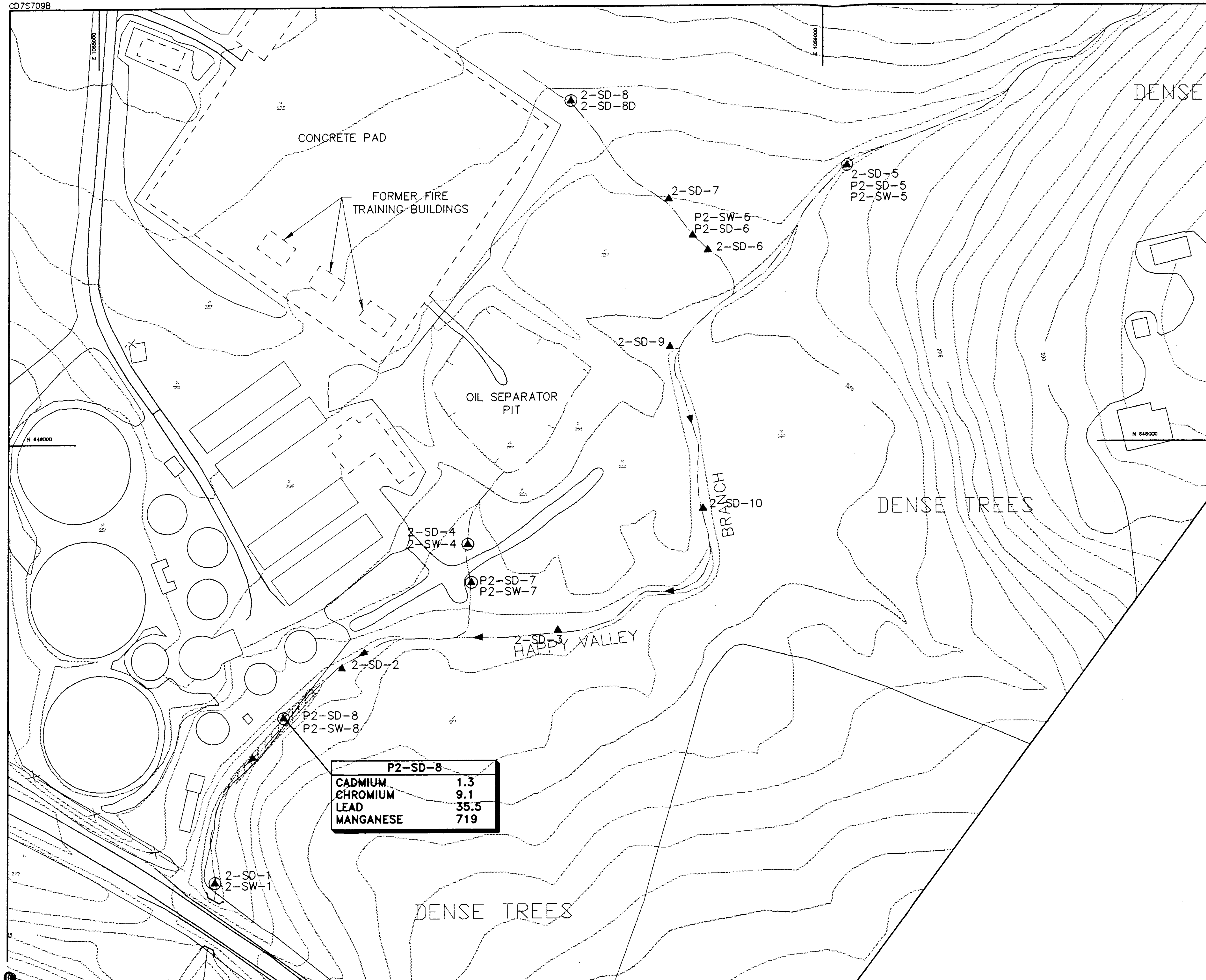
NOTES:

1. ANALYTICAL RESULTS ARE IN mg/kg.
2. CONCENTRATIONS FOR SAMPLE LOCATIONS P1-SD-XX ARE BASED ON 1991 DATA.
3. CONCENTRATIONS FOR SAMPLE LOCATIONS 1-SD-XX ARE BASED ON 1994 DATA.



Figure 2-5A CONTAMINANTS IN SEDIMENT EXCEEDING PRELIMINARY CLEANUP GOALS
SITE 1 – OLD LANDFILL AREA
NAVAL TRAINING CENTER – BAINBRIDGE

CD7S709B




| P2-SD-8 | |
|---|---|
| CADMIUM | 1.3 |
| CHROMIUM | 9.1 |
| LEAD | 35.5 |
| MANGANESE | 719 |

| PRELIMINARY SEDIMENT CLEANUP GOALS | |
|---|---|
| CONTAMINANT | CLEANUP GOALS |
| CADMIUM | 1.0 |
| CHROMIUM (TOTAL) | 9.04 |
| LEAD | 24.0 |
| MANGANESE | 602 |

NOTES:
1. ANALYTICAL RESULTS ARE IN mg/kg.
2. CONCENTRATIONS ARE BASED ON 1994 DATA

LEGEND

2-SD-3 ▲ SEDIMENT SAMPLE LOCATION
2-SW-3 ○ SURFACE WATER LOCATION
REMOVED STRUCTURE
ESTIMATED AREA OF CONTAMINATION

N

SCALE IN FEET
0 150 300 450

Figure 2-6 CONTAMINANTS IN SEDIMENT EXCEEDING CLEANUP GOALS
SITE 2 - FIRE TRAINING AREA
NAVAL TRAINING CENTER - BAINBRIDGE

# 3 Identification and Screening of Remedial Technologies

## 3.1 Identification of Applicable Remedial Technologies and Preliminary Screening

The purpose of this section is to identify and screen potential remedial action technologies which may be applicable to remediation of the groundwater and sediments at the NTC sites. Each technology was subject to a preliminary screening process and evaluated in terms of effectiveness, implementability, and relative cost. After the preliminary screening, remedial technologies deemed feasible will be combined into comprehensive alternatives in Section 4 and evaluated on a broad basis of implementability, effectiveness, and cost to develop a range of alternatives to be analyzed in detail in Section 5. No remedial technologies were identified for surface water because of the nature of the surface water at these NTC sites (i.e., very small ditches/streams). Surface water will be indirectly addressed by groundwater and sediment remedial actions.

## 3.2 Groundwater

Groundwater at Site 1 is contaminated with TCE, vinyl chloride and metals. At Site 2, contamination consists of metals and PAHs. Contamination in the groundwater represents a hazard to human health. Using the cleanup goals determined in Section 2.3.1.1. and the RI analytical data, groundwater samples with concentrations exceeding the cleanup goals were identified (see Table 2-3 and Figures 2-1 and 2-2).

On-site and off-site technologies for contaminated groundwater include:

- In situ treatment,
- Biological treatment,
- Physical/chemical treatment,
- Containment,
- Recovery,

- Discharge/disposal,
- Institutional controls, and
- No action.

A summary of the groundwater remedial technology screening process is presented in Table 3-1.

### 3.2.1 In Situ Treatment

In situ treatment is a remediation technology generally applicable to sites with large quantities of organic contamination. Contamination included TCE and vinyl chloride at Site 1, and PAHs at Site 2, but the limited area of contamination and the levels detected do not justify the costs associated with considering this technology.

### 3.2.2 Ex Situ Biological Treatment

All ex situ biological treatment systems are designed to expose wastewater containing biologically degradable organic compounds to a suitable mixture of microorganisms in a controlled environment that contains sufficient essential nutrients for the biological reaction to proceed. This technology is not applicable to the metal contamination found at Site 1 and Site 2. Since chlorinated compounds (TCE and vinyl chloride) detected at Site 1 are generally difficult to biodegrade, this treatment will not be retained for further consideration.

### 3.2.3 Physical and Chemical Treatment

Physical and chemical treatment processes are used to treat inorganic and organic waste that may be nonbiodegradable or resistant to biodegradation, as described below.

- **Gravity Separation** is used to treat two-phased aqueous wastes. It can be used to separate free gasoline or fuel oil from a fuel-contaminated aquifer. This process offers a simple, effective means of phase separation, provided the oil and water phases separate adequately within the residence time of the tank. The cost associated with this technology is low compared with that of other technologies. Because two phased aqueous wastes were not detected in the groundwater at either site, gravity separation will not be considered as an applicable technology.

- **Filtration** is a well-established unit operation for achieving supplemental removal of residual suspended solids from wastewater by passing the groundwater through a filter media. Common particulates removed in water treatment filtration are clay and silt, colloidal and precipitated natural organic matter, metal salt precipitates from coagulation, lime softening precipitates, iron and manganese precipitates, and microorganisms. This process could be used as an additional pretreatment step, following sedimentation, to enhance any primary groundwater treatment option. Filtration could also be used to remove residual floc from the effluent of precipitation, flocculation, and sedimentation processes. This technology is readily implementable and is well established and widely used. The equipment, labor, and materials necessary are readily available. Disposal of settled out solids would be required. Capital and O&M costs associated with filtration are relatively moderate. Although feasible, more promising and site appropriate technologies can be used for suspended sand removal, if needed. Therefore filtration will not be considered further.

- **Precipitation/Coagulation/Flocculation.** This process removes heavy metals and colloidal and dissolved solids from wastewater. It is not effective, however, in removing soluble organic compounds. Precipitation is a chemical (or electrochemical) process by which soluble metallic ions and certain anions are converted to an insoluble form for subsequent removal from the wastewater stream. This process commonly removes particulate suspensions of clay- and silt-based turbidity, natural organic matter, microbial contaminants, toxic metals, synthetic organic chemicals, iron, and manganese. Various coagulants and coagulant aids such as alum, ferric chloride, sodium sulfide, organic polymers, and sodium hydroxide are selected, depending on the specific waste materials to be removed, and are rapidly mixed with the wastewater to cause the colloidal particles to agglomerate into a floc large enough to be removed by a subsequent sedimentation, filtration, and/or clarification process. The performance of the process is affected by chemical interactions, temperature, pH, solubility variances, and mixing. This system would be relatively simple to construct and operate and is well established. The necessary materials and equipment are readily available from several vendors. The cost for this system is moderate in terms of capital cost, but may be high in O&M costs because of the continuous chemical requirements and disposal costs of the generated sludge. This process will be considered for both sites.

- **Flotation** is used to remove oils and other suspended substances with densities less than that of water or, in the case of dissolved air flotation, particles that may be slightly heavier than water through adsorption to bubbles. As with conventional clarifiers, flocculants are frequently employed to enhance the efficiency of flotation units. Although flotation is often referred to in the context of dissolved air flotation, other technologies such as oil/liquid skimming and solids skimming are also flotation operations and are sometimes an integral part of standard clarification. Costs associated with this technology are low relative to other technologies. Flotation is employed mainly for the treatment of nutrient-rich reservoir water that may contain heavy algae blooms and for low-turbidity, low-alkalinity, colored water or for separating oil and grease that have specific gravity less than that of water. Since this is not typical at either site, flotation will not be retained as a viable technology.

- **Sedimentation** is designed to let wastewater flow slowly and quiescently, permitting solids denser than water to settle to the bottom and materials less dense than water (including oil and grease) to flow to the surface. The sedimentation process would not remove soluble organic contaminants, such as TCE, or soluble metal contaminants. Polymers may be added to the wastewater to enhance liquid-solid separation. Settled solids form a sludge at the bottom of the clarifier, which is usually pumped out continuously or intermittently. Oil and grease and other floating materials may be skimmed off the surface. Sedimentation would most likely be used as a pretreatment step for solids removal before granular activated carbon, air stripping, or ultraviolet oxidation. This technology is readily implementable and is well established and widely used. The equipment, labor, and materials necessary are readily available. Disposal of the settled-out solids would be required. Capital and O&M costs associated with sedimentation are relatively moderate. This technology will be retained for further consideration as a pretreatment step for metals removal at both sites, if needed.

- **Adjustment of pH** is used to increase or reduce the pH of a wastewater stream. Alkaline wastewater may be neutralized with hydrochloric acid, carbon dioxide, sulfur dioxide or, most commonly, sulfuric acid. Acidic wastewaters may be neutralized with limestone or lime slurries, soda ash, caustic soda, or anhydrous ammonia. Often, a suitable pH can be achieved through the mixing of acidic and alkaline process wastewaters. Selection of pH adjustment agents is based on cost, availability, ease of use, reaction by-products, reaction rates, and quantities of sludge formed. An optimal chemical equilibrium may be reached to destabilize the species in the water to form agglomerations that can be removed. Thus, pH adjustment can be used to optimize the precipitation process, as well as the performance of other types of pretreatment systems (e.g., coagulation and flocculation). This process is readily implementable. The cost of this treatment would be relatively moderate compared with other treatment technologies. The chemicals that are required are relatively inexpensive; however, the sludge generated from this process would require disposal. pH adjustment was retained for further consideration as a pretreatment step; if needed.

- **Chemical Oxidation** is used primarily for detoxification of cyanide and for treatment of dilute waste streams containing oxidizable organics. Aldehyde, mercaptans, phenols, benzidine, unsaturated acids, and certain pesticides have been treated using this method. Chemical oxidizers employed include hydrogen peroxide, potassium permanganate, chlorine, ozone, and chlorine dioxide. The costs associated with chemical oxidation are low relative to other technologies.

The types of contaminants present in the groundwater, however, are not readily susceptible to chemical oxidation techniques. Therefore, this method will not be considered further as part of a remedial action alternative.

- **Chemical Reduction** involves addition of a reducing agent that lowers the oxidation state of a substance to reduce toxicity or solubility or to transform it to a form that can be easily handled. Chemicals such as hexavalent chromium, lead and mercury are good candidates for chemical reduction. The costs associated with chemical reduction are low compared with other technologies. Chemical reduction will not be retained for further consideration for metals, because the specific metals in site groundwater can be treated with more appropriate technologies.

- **Activated Carbon Adsorption** is a well-demonstrated technology that removes organics from aqueous waste streams by adsorbing the compounds onto the large internal pore surface area of activated carbon. The process has been demonstrated on a variety of organics, particularly those exhibiting low solubility and high molecular weight, and has been demonstrated as an effective and reliable means of removing low-solubility organics over a broad concentration range. Activated carbon can be used in a treatment column or by adding powdered activated carbon directly to contaminated water. In column applications, adsorption involves the passage of contaminated water through a bed of activated carbon, which absorbs the contaminants into the carbon. Continuous carbon treatment completely removes organic compounds from the aqueous solution until the column becomes saturated. When the activated carbon has been used to its maximum adsorptive capacity (i.e., spent), it is then removed for disposal, destruction, or regeneration.

  Slugs of groundwater containing chlorinated organics would not affect effluent quality, although total bed capacity (i.e., time to saturation) would vary.

Carbon adsorption can be readily implemented at hazardous waste sites and can remove dissolved organics from aqueous wastes to levels below 1 ppb. However, carbon adsorption will not treat the metals present in the waste stream. Additional treatment to remove metals, such as precipitation, may be needed to meet the RAOs. A carbon adsorption system would be relatively simple to construct and operate. The necessary materials and equipment are readily available from several vendors. O&M requirements would be minimal, involving monitoring of the effluent for breakthrough. The cost of activated carbon adsorption is relatively moderate in terms of capital and O&M costs. This process will not be considered further because more promising technologies exist to treat the organic-contaminated groundwater at Sites 1 and 2.

- **Wet-Air Oxidation** is a process whereby elevated temperature and high pressure are applied to the waste to oxidize the organic compounds completely. Costs associated with wet-air oxidation are moderate relative to other technologies. A major disadvantage associated with this process is the high-strength recycle liquor produced. This technology is primarily applicable on extremely contaminated waters. Because none of the source areas for consideration at the NTC sites contains extremely contaminated waters, this process will not be retained for consideration.

- **Air Stripping/Steam Stripping** includes mass transfer processes in which volatile organic contaminants in water are transferred to gas. Stripping processes maximize contact between contaminated aqueous solutions and air, and transfer volatile organics to the air to form a gaseous effluent. Air stripping is effective for diluted waste streams containing highly volatile organics. Its effectiveness is generally contaminant specific and is not influenced by the quality of the water. During remediation, operable parameters (e.g., air and groundwater flow rates) could also be adjusted so that the effluent would still comply with chlorinated organic discharge limitations. Pretreatment of the groundwater may be required to prevent potential plugging or fouling associated with the moderately high iron and manganese concentrations in the groundwater. This may be accomplished by sedimentation and/or filtration, precipitation, coagulation, and flocculation.

Steam stripping and elevated temperature air stripping are effective for more concentrated waste streams containing less volatile organics. Steam stripping is a variation of distillation whereby steam is used as both the heating medium and the driving force for the removal of volatile materials. For employment of steam stripping, steam is introduced into the bottom of a tower. As it passes through the wastewater, the steam vaporizes and removes volatile materials from the waste and then exits via the top of the tower. Although commonly employed as an in-plant technology for solvent recovery, steam stripping is also used as a wastewater treatment process.

The TCE and vinyl chloride present in the groundwater at the Site 1 are readily air-stripped. Some of the other semivolatiles found, at levels below screening values, can also be air stripped out of the waste stream. An air stripping system is relatively simple to construct and operate. This technology is well established, and the necessary materials, equipment, and personnel are readily available through a variety of vendors. Maintenance requirements are expected to be minimal and would include periodic inspection of the air stripping column for plugging and bacterial growth. Power consumption should not be excessive because of the relatively low air flow rates required. Air stripping systems generally have high capital costs, but are moderate in terms of O&M costs. Air stripping will be retained as a viable remedial technology at Site 1; however, steam stripping will not be retained, as Site 1 does not have a concentrated waste stream.

- **Ultraviolet Oxidation.** The Ultraviolet (UV) light chemical oxidation process is applicable for removal/destruction of organic contaminants in groundwater. Using hydrogen peroxide ($H_2O_2$) as a reagent, this process reduces the contaminants to acceptable levels or destroys them completely. UV light catalyzes the chemical oxidation of organics in groundwater by its combined effect on the contaminants and the $H_2O_2$. The process entails extracting the contaminated groundwater and passing it through the oxidation chamber (the mixture flows past the UV lamps, housed in quartz tubes). The contaminants will absorb the UV light, and this light energy activates the contaminant so that is more readily oxidized by the $H_2O_2$. Pretreatment would be needed to remove metal contaminants and suspended particles. The purified water is either reinjected or disposed of properly. Significant pretreatment may be required, as UV oxidation is sensitive to interference and the presence of organic material and suspended solids. Other substances (e.g., bicarbonate ions) may decrease the effectiveness of the process in destroying the target compounds. Therefore, the effectiveness of this technology in treating the contaminants would have to be evaluated in a treatability study. This process has relatively high capital costs because it requires electricity for operation. Treatability testing also accounts for the high cost of this system. This technology has been shown to be effective on chlorinated organics; however, because more appropriate technologies exist for site contaminants, UV oxidation will not be considered further.

- **Reverse Osmosis (RO)** uses a semipermeable barrier that is permeable to water but impermeable to most dissolved contaminants, organic and inorganic. Pretreatment of the contaminated water is usually required to prevent plugging. Although the cost of RO is low relative to other technologies, RO is generally used for commercial purposes, rather than for waste treatment. Therefore, it will not be retained as a viable technology for these sites.

- **Ultrafiltration (UF)** is a physical unit process used to segregate dissolved or suspended solids from a liquid stream on the basis of molecular size. High-molecular-weight solutes or colloids are separated from a suspension or solution through the use of semipermeable polymeric membranes. The process has been successfully applied to both homogeneous solutions and colloidal suspensions, which are difficult to separate practically by other techniques. Although costs associated with UF are low compared with other technologies, this process is not applicable and will not be considered further for Site 1 or Site 2 contaminants because they generally do not exist as high-molecular-weight solutes or colloids.

### 3.2.4 Containment Barriers

Impermeable barrier walls are used as both vertical and horizontal containment methods. The primary functions of the barriers are to divert groundwater so that it does not contact waste materials and become contaminated and/or to prevent contaminated groundwater and liquid waste material from migrating off the disposal site. This alternative will not be considered however due to the nature of the bedrock found at the NTC sites. The bedrock is fractured, thereby making it difficult to predict the groundwater flow and making it impossible to divert groundwater in the desired direction. Also, the aquifer contains COPCs above cleanup goals and is located in the overburden and bedrock and therefore no discernible interface exists to establish containment boundaries.

### 3.2.5 Groundwater Recovery

Methods of groundwater recovery are available to actively mitigate groundwater contamination. Groundwater pumping is used to control contaminant plumes through adjustment of the water table elevation, containment of the plume, or removal of the plume. Pumping methods are most effective at sites where underlying aquifers have high hydraulic conductivities and contaminants move readily in water. Groundwater can be recovered through the use of groundwater extraction wells and/or pumps and subsurface drains. The collected groundwater must then be treated and/or disposed of. Effectiveness, however, decreases with depth, and cost increases with depth. This technology will be retained for further consideration.

### 3.2.5.1 Groundwater Extraction

Groundwater extraction methods involve the use of extraction wells and pumps to actively remove groundwater and to manipulate the groundwater table. The groundwater collected during pumping would require treatment and disposal. The selection of an appropriate well system depends on a number of factors, including the depth and area of contamination and the hydrologic and geologic characteristics of the aquifer. Because of limitations on the speed with which contaminants adsorbed to the aquifer matrix can partition into the groundwater, groundwater extraction systems are sometimes operated in a pulse-pumping mode. In this mode, the pumps operate intermittently, allowing the adsorbed contaminants to diffuse into the groundwater during the "off" periods. Such operation limits the amount of low-contaminated groundwater removed, thus reducing subsequent treatment costs. Extraction wells are effective in both containment and restoration of aquifers. In general, restoration of the aquifer would require the removal of large volumes of contaminated groundwater because of mass-transfer limitations. The affected aquifer beneath the NTC site is a relatively high permeable aquifer. Hydraulic conductivity ranged from $8.5x10^{-4}$ to $2.6x10^{-2}$ cm/sec at Site 1 and ranged from $1.25x10^{-3}$ to $7.5x10^{-2}$ cm/sec at Site 2.

This technology is readily implementable and is well established and widely used. The equipment, labor, and materials necessary are readily available. Impacts on surrounding land use from the installation of extraction wells would be minimal. Hydraulic effects on surrounding surface water bodies can be minimized or eliminated by adjusting extraction well pumping rates to keep capture zone limits at the plume boundaries. The cost for extraction wells is relatively moderate in terms of capital and low in terms of O&M. Substantial costs are encountered, however, for extracted groundwater treatment and disposal. This technology will be retained for further consideration.

### 3.2.5.2 Subsurface Drains

Subsurface drains include any type of buried conduit used to convey and collect contaminated groundwater by gravity flow. Subsurface drains essentially function like a line of extraction wells and therefore can perform many of the same functions as wells. However, use of subsurface drains is generally limited to shallow depths but may be well suited to address groundwater seeps. Also, due to the fractured nature of the bedrock, subsurface drains may not be effective in collecting groundwater caught in the fractures. In addition, although costs associated with subsurface drains are low to moderate relative to other technologies, groundwater contamination has been found in the deep wells (typically, 30-40 feet BGS).

### 3.2.6 Discharge/Disposal

The four technologies identified for groundwater discharge or disposal are publicly owned treatment works (POTW), deep-well injection, reinjection to groundwater, and surface-water discharge.

#### 3.2.6.1 Publicly Owned Treatment Works

Contaminated groundwater from the site may be treated on site to meet local pretreatment standards, and then discharged in limited quantities to the city of Port of Deposit POTW for final disposal. POTW treatment standards would likely be less stringent than NPDES discharge limits, which are required for surface water discharge. Therefore, less pretreatment may be required prior to this discharge option. Treated water would be discharged by the POTW to the Susquehanna River. Port Deposit Water Treatment Plant has a total capacity of 150,000 gpd with a current flow of 110,000 gpd (McAffey, 1999). Therefore, the POTW does have the capacity to receive discharge from the sites. However, other technologies will be considered because of the distance to POTW.

#### 3.2.6.2 Deep-Well Injection

Deep-well injection is a method for disposal of highly contaminated or very toxic wastes not easily treated or disposed of by other methods. Deep-well injection is limited geographically because of the geological requirements of the system. A substantial and extensive impervious caprock strata must exist, overlying a porous strata that is not used as a water supply or other source.

Deep wells are drilled through impervious caprock layers into such unusable strata as brine aquifers. The wells are usually more than 3,000 feet deep and may reach depths of more that 15,000 feet. Pretreatment of the waste for corrosion control and especially for the removal of suspended solids is normally required to avoid plugging of the receiving strata. Additional chemical conditioning could be required to prevent the waste and the constituents of the receiving strata from reacting and causing plugging of the well. Costs associated with deep-well injection are moderate to high relative to other technologies. This will not be retained for further consideration because of permitting problems/agency approval and because of a lack of data at this time to substantiate the existence of favorable deep geologic conditions.

#### 3.2.6.3 Reinjection to Groundwater
Treated groundwater may be reinjected into the aquifer from which it was withdrawn. This approach can be used to help direct the flow of contaminated groundwater toward the extraction wells or recovery trenches.

Recharge to the aquifer via injection wells allows the most precise control over the subsurface water movement and is quite similar to in situ solution mining techniques, except that no chemicals are added to the injection water. The injection wells can also be placed so that the contaminant plume may be forced by increased hydraulic gradient toward the extraction wells, thus facilitating the removal of contaminated water. Injection, however, may also locally increase the downward vertical gradient and subsequent downward movement of contamination. Another potential problem with reinjection includes clogging of the well screens with grit and precipitated matter, which can increase the energy requirements for pumping. In addition, reinjection may cause localized raising of the groundwater table, which may interfere with other activities on site. Furthermore, to reinject the aquifer, the effluent must be in pristine condition. The costs associated with this technology are moderate relative to other technologies. Due to many potential problems and obstacles associated with this technology, it will not be retained for further consideration.

#### 3.2.6.4 Surface-Water Discharge
Treated groundwater may be discharged to a nearby surface water body. A NPDES permit would be required for the discharge. Effluent standards would have to be met for all permit parameters and not just for groundwater contaminants determined to be cleanup goals. Because this technology is easily implementable and has relatively low associated costs, surface water discharge will be retained for further consideration.

### 3.2.7 Institutional Controls
Institutional controls are measures taken to protect human health until contaminants in the groundwater have met remedial cleanup goals. Institutional controls can include deed restrictions, regulatory restrictions on the construction and use of private wells, and well-use advisories.

Access restriction is an effective measure for limiting exposure to the public. It is generally used at sites where the appropriate cleanup levels cannot practicably be achieved or where contamination is not deemed as a serious threat to human health or the environment. Access restrictions can be achieved through the use of fences, deed restrictions, or zoning laws.

Deed restrictions on future land use could be implemented to limit exposure to contaminated groundwater. Access restriction is very inexpensive relative to treatment. Institutional controls may be combined with other technologies and with environmental monitoring. Institutional controls will be retained for further evaluation.

### 3.2.8 No Action

The "no action" alternative would not include any type of environmental monitoring, institutional controls, or remedial action. No costs are associated with this alternative. No action will be retained and developed into a remedial alternative for the NTC sites, as required by the NCP.

## 3.3 Sediment

Sediment contamination that may represent a hazard to ecological receptors consists of metals and PAHs at Site 1, and metals at Site 2. Using the preliminary remediation goals determined in Section 2.3.2.1. and the RI analytical data, sediment samples with concentrations exceeding the cleanup goals were identified (see Table 2-6 and Figures 2-5 and 2-6).

On-site and off-site technologies for addressing contaminated sediments include:

- Sediment removal,
- Sediment containment,
- On- and off-site treatment of sediments,
- Sediment disposal,
- Institutional controls, and
- No action.

A summary of the sediment remedial technology screening process is presented in Table 3-2.

### 3.3.1 Removal
The process of removing contaminated sediments from surface water bodies involves two broad types of technologies: excavation and dredging. These technologies are discussed below.

#### 3.3.1.1 Excavation
Excavation of sediments utilizes conventional excavation equipment and is applicable for sediment removal from the two unnamed streams at Site 1 (Landfill) and Happy Valley Branch at Site 2 (Fire Training Area). Excavation equipment is readily available, and common equipment such as backhoes can be used to excavate any type of material. Excavation is directly applicable to NTC site conditions. The sediments are contained in very small, narrow ditches, similar to typical road-side drainage ditches, which are maintained by excavation. Any water flowing in the ditches would be diverted downstream of the active work area to minimize suspension of soil materials. At the NTC, excavation with conventional equipment would be effective in the removal of contaminated sediment occurring in its shallow ditches. Therefore, removal of sediments by excavation is retained as an applicable remedial technology.

#### 3.3.1.2 Dredging
Dredging refers to the removal of bottom sediments from a water body typically much more significant than the ditches at NTC. This process has been used for years to widen or deepen harbors and navigable waters. In recent years, dredging has also been employed in the removal of sediments that have been contaminated by hazardous constituents.

Dredging and its process options are applicable for removal of aquatic sediments found in locations such as rivers, lakes, and harbors. However, sediments found at the NTC sites exist in shallow-water ditches of narrow widths. These site-specific conditions would favor the use of easily available and easily maneuverable conventional excavation equipment. Vacuum dredging is another dredging process that has been considered. However, due to the rocky nature of the NTC Site streams, this process would not be practical. Thus, dredging will not be retained for further analyses.

### 3.3.2 Containment
Containment uses different technologies to isolate or stabilize contaminated sediments from water that could serve to transport contaminants. Permanent containment methods may include use of caps, dikes, impermeable barriers, or in-situ grouting. Temporary

containment generally involves the use of dikes or berms, although capping materials can be used on a temporary basis as well.

The above-mentioned containment technologies could be effective in stabilizing sediments. Covering and sealing methods would be cost-effective and could be easily implemented at the site. However, placing covering or sealing materials on the shallow streams would most likely damage them and permanently change the local ecosystem. Also, this method is not effective in the long term as erosion over time would cause degradation and freeze/thaw effects would adversely impact the containment system. Therefore, containment methods would not be effective in meeting the RAOs and are not considered for further evaluation.

### 3.3.3 On- and Off-site Treatment

To meet sediment cleanup goals, there are several options available. Sediments could be removed, treated on site to meet the cleanup goals, and backfilled. Excavated sediments could also be transported off site for treatment and disposal and clean backfill placed on site. None of the contaminated sediments at the NTC sites are listed hazardous wastes. However, at Site 1, based on total contaminant concentration, lead in aqueous form may fail TCLP tests and could therefore be a characteristic waste. The contaminated sediments at Site 1 would then be classified as RCRA hazardous waste, requiring treatment to universal treatment standards prior to off-site disposal.

On and off-site treatment of contaminated sediments includes techniques falling into three major categories:

- Thermal destruction,
- Physical/chemical treatment, and
- Biological treatment.

A description of each of the available remedial technologies is presented below.

#### 3.3.3.1 Thermal Destruction

Thermal destruction technologies use high-temperature oxidation (except pyrolysis which operates in the absence of oxygen) under engineered conditions to degrade an organic contaminant into products that generally include carbon dioxide, water vapor, sulfur dioxide, nitrogen oxides, gases, and ash. Thermal destruction technologies are used primarily to treat organics. Because metals and PAHs are the contaminants of concern at the NTC sites, this technology is not cost effective and will not be considered.

#### 3.3.3.2 Physical/Chemical Treatment

Physical/chemical treatment technologies utilize physical or chemical alterations to the sediment matrix or the contaminants. The matrix may be altered so contaminants are less mobile, or contaminants may either be altered to a less toxic form or completely destroyed and rendered harmless. Physical/chemical treatment technologies are applicable to both organic and inorganic contaminants. These technologies can be conducted ex situ, where the contaminated media is excavated, treated, and either disposed off site or backfilled; or in situ, where the contaminated media are left in-place and the reactants are delivered to the media. Results of TCLP tests will dictate whether universal treatment standards would also have to be met in addition to cleanup goals. Ex situ physical/chemical technologies are presented below followed by in situ treatment technologies.

- **Thermal Desorption.** This technology utilizes relatively low-to-medium temperatures (300 to 600°C) to volatilize organic contaminants from the sediment matrix. Since metals and PAHs are the contaminants of concern, thermal desorption will not be retained for further analyses.

- **Dechlorination Processes.** These processes have been used to treat soils and sediments contaminated with chlorinated organic compounds such as PCBs and dioxins. These processes are not applicable to the metals found in the sediments or the organic compounds found at Site 1 and, therefore, this remedial technology will not be retained for further analyses.

- **Soil Washing.** Soil washing is a water-based contaminant removal process that removes both organic and inorganic contaminants from soils or sediments in one or a combination of ways:

1) By concentrating soils or sediments into a smaller volume through particle size separation; and

2) By dissolving or suspending in the wash solution.

Soil washing systems are highly effective on soils or sediments contaminated with a wide variety of organic indigenous contaminants. The process consists of mixing contaminated sediments with wash water and possibly surfactants, and/or chelating agents to remove contaminants from sediments and transfer them to the washwater. The solids and washwater are then separated, and the soil is rinsed with clean water. Suspended soil particles are recovered as sludge directly from the spent wash water using gravity separation and, when necessary, through flocculation with a polymer or other chemical. The separated small particles (sludge) will most likely be of less quantity but carry higher levels of contamination than the untreated sediment. Therefore, the sludge may need further treatment or secure disposal (EPA 1994). Sediment contamination primarily consists of metals which would require additional treatment such as gravity separation. Also, effectiveness of this technology is dependent on contaminant concentrations, sediment-particle-size distribution, and the number of times the sediments must be recycled through the system to meet the treatment goals. This will add to the overall cost of this technology. This technology is available for both on-site and off-site implementation. Soil washing technology will not be retained for further analyses.

- **Solvent Extraction.** Solvent extraction uses nonaqueous chemical agents in a leaching process to desorb organic and inorganic contaminants from the sediment matrix into the solvent phase. Variations of this technology have used a variety of solvents to separate classes of contaminants in a series of processes. The liquid waste stream is then treated to remove the contaminants, and the solvent is recycled, if possible. After mixing, the solids are recovered and rinsed with a neutralizing agent (if needed), dried, and placed back on site. The technology is readily available for on- or off-site operation. Following solvent extraction, sediments would need to be washed to remove traces of solvents prior to replacement. Although there is a potential to achieve high removal efficiencies, evaluation on a unit cost basis makes this technology prohibitive. This is due to the costs of the treatability study and capital equipment versus the small volume requiring treatment. Therefore, this technology will not be retained for further analyses.

- **Solidification/Stabilization (S/S).** S/S is a technique wherein the contaminants are bound in a solid matrix through the addition of solidifying agents such as pozzolanic ash, cement, or other admixtures. Typically, solidification produces a monolithic block with high structural integrity. Stabilization agents may be added along with solidifying agents to chemically convert hazardous contaminants to less toxic or less leachable forms. The S/S process is available from a number of vendors who may also offer proprietary processes. The S/S process would include excavation, dewatering, screening, addition of solidification and stabilization agents, and curing of the monoliths. Cured monoliths could be backfilled at the NTC or disposed off site. On-site disposal of solidified materials in the creek, however, could permanently alter it and make the re-establishment of the ecosystem difficult. Metals are best treated by this technology because they can actually bond with the solidification agents; however, the long-term effectiveness of such a situation cannot be ensured. Since contamination consists of metals, this technology will be retained for further analysis only as it might be required for off-site disposal.

#### 3.3.3.3 Biological Treatment

Bioremediation refers to the breakdown of organic compounds by microorganisms. Making use of indigenous or exogenous bacteria, bioremediation techniques attempt to optimize the ability of the microorganism to reduce complex organic compounds to simpler ones, and completely mineralize others. Bioremediation is not an applicable technology for metals contamination, the principle sediment contaminant, and therefore, it will not be retained for further analyses.

#### 3.3.3.4 In Situ Treatment

A number of technologies have been developed that employ physical-chemical or biological means in situ to immobilize or remove waste constituents. Since sediments would remain in place, cleanup goals would have to be met for metals regardless of TCLP test results. In situ treatment technologies are discussed below.

- **In situ Bioremediation.** In situ bioremediation refers to the on-site breakdown of organic compounds by action of microorganisms. Bioremediation is not effective for inorganic contaminants. Therefore, in situ bioremediation is not retained for further analyses.

- **In situ solidification/stabilization (S/S).** The S/S technology was detailed previously. In situ S/S uses specialized equipment to deliver solidifying/stabilizing agents. The in situ S/S process is more applicable for sites in which extensive contamination exists at greater depths and excavation of contaminated materials would be costly and environmentally unsafe. The long-term durability of the solidified/stabilized media in the subsurface environment is currently under investigation.

  Solidification/Stabilization would permanently alter the hydraulics of the creeks and would make the re-establishment of the ecosystem difficult. Therefore, in situ S/S will not be retained.

### 3.3.4 Disposal

Land disposal often represents the quickest, most direct remedial action for a site. The Hazardous and Solid Waste Amendment (HSWA) to RCRA mandates stringent land disposal restrictions (LDRs) that prohibit the land disposal of RCRA hazardous wastes unless the waste materials meet the levels of universal treatment standards identified in 40 CFR Part 268. Contaminated sediments at Site 1 may fail TCLP tests for lead in aqueous form. If this is the case, contaminated sediments at Site 1 would be considered characteristic waste. The wastes would then have to be treated to meet universal treatment standards prior to land disposal.

Disposal options for contaminated sediments at Site 1 and Site 2 are discussed below.

- On-site Disposal of excavated sediments could be disposed in an on-site waste disposal facility assuming favorable TCLP test results of metals. Any hot spots not meeting these conditions would require off-site treatment and/or disposal. An on-site disposal facility, for low-hazard or detoxified wastes, not specifically designated as RCRA wastes or hazardous wastes per states regulations, would not be required to meet all RCRA requirements. Long-term monitoring and operation and maintenance of the disposal facility would be required. In addition, future use of the site would need to be restricted. Even though a portion of Site 1 consists of a designated landfill, due to the small volumes of contaminated material requiring disposal, disturbing the existing landfill cap would not be cost effective. Therefore, on-site disposal in the landfill will not be retained as a remedial action.

- Off-site Disposal of contaminated materials involves hauling excavated material to a commercial disposal facility. Sediments may also require dewatering before off-site transportation. Based on the contaminant concentration for lead in aqueous form at Site 1, lead-contaminated sediments may fail TCLP tests and thus would be classified as hazardous materials. Any hot spots that fail TCLP tests require treatment at the off-site facility to meet LDRs prior to disposal. In the event of favorable TCLP test results of metals, excavated sediments could be disposed off-site in a sanitary waste landfill without treatment. Off-site disposal technology is retained for further analysis.

### 3.3.5 Institutional Controls

Institutional controls are measures taken to protect human health until contaminants in the sediment have met remedial cleanup goals. Institutional controls can include access restrictions, deed restrictions, or regulatory restrictions use of sediments from the streams. However institutional controls will not protect potential ecological receptors.

Access restriction is an effective measure for limiting exposure to the public. It is generally used at sites where the appropriate cleanup levels cannot be practicably achieved or where contamination is not deemed as a serious threat to human health. Access restrictions can be achieved through the use of fences, deed restrictions, or zoning laws.

Deed restrictions on future land use could be implemented to limit public exposure to contaminated sediments. Access restriction is very inexpensive relative to treatment. Institutional controls may be combined with other technologies and with environmental monitoring. Since the surface water/sediments are not a concern for humans, and institutional controls will not protect ecological receptors, these controls will not be retained for further evaluation.

### 3.3.6 No Action

The "no action" alternative would not include any type of environmental monitoring, institutional controls, or remedial action. No costs are associated with this alternative. No action will be retained and developed into a remedial alternative for the NTC sites, as required by the NCP.

## Table 3-1

## REMEDIAL TECHNOLOGY SCREENING SUMMARY FOR GROUNDWATER
## Navy Training Center - Site 1 (Landfill) and Site 2 (Fire Training Area)

| GRA/Remedial Technology | Retain Technology | Comment |
|---|---|---|
| **In Situ Treatment** | No | Low organic levels do not justify the costs associated with this technology and this technology is ineffective for inorganic contaminants. |
| **Ex Situ Biological Treatment** | No | Chlorinated compounds (TCE and vinyl chloride) detected at Site 1 are difficult to biodegrade and this technology is not applicable to metal contamination. |
| **Physical and Chemical Treatment** | | |
| Gravity Separation | No | Gravity separation effective for two-phased aqueous wastes. These wastes were not detected in the groundwater at either site. |
| Filtration | No | Although feasible, more promising and appropriate technologies can be used. |
| Precipitation/Coagulation/Flocculation | Yes | |
| Flotation | No | Flotation effective for treatment of nutrient-rich reservoir water with heavy algae blooms and for low-turbidity, low-alkalinity, colored water, or oil-water separation which do not exist at either site. |
| Sedimentation | Yes | |
| Adjustment of pH | Yes | Retain for use with other technologies as a pretreatment step as needed. |
| Chemical Oxidation | No | Used for detoxification of cyanide and treatment of dilute waste streams containing oxidizable organics. These types of contaminants are not present in the groundwater at either site. |
| Chemical Reduction | No | More appropriate technologies exist for the metals found in site groundwater. |
| Activated Carbon Adsorption | No | More appropriate technologies exist for the organics found in site groundwater. |

## Table 3-1

## REMEDIAL TECHNOLOGY SCREENING SUMMARY FOR GROUNDWATER
### Navy Training Center - Site 1 (Landfill) and Site 2 (Fire Training Area)

| GRA/Remedial Technology | Retain Technology | Comment |
|---|---|---|
| Wet-Air Oxidation | No | This technology primarily for extremely contaminated water, which are not found water either site. |
| Air Stripping/Stream Stripping | Yes - Site 1 | Air stripping will be considered for the organics present at Site 1. Site 2 does not contain volatile organics and therefore this technology will not be considered. Steam stripping will not be considered at either site as concentrated waste streams do not exist. |
| Ultraviolet Oxidation | No | Will not be considered for the chlorinated organics present at Site 1. Although feasible, more promising, cost effective, and appropriate technologies can be used. Site 2 does not contain chlorinated organics and therefore this technology will not be considered. |
| Reverse Osmosis (RO) | No | RO is generally used for commercial purposes, rather than waste treatment. |
| Ultrafiltration (UF) | No | This technology used primarily for high-molecular-weight solutes or colloids which do not exist at either site. |
| **Containment Barriers** | No | Due to fractured nature of the bedrock, containment barriers would not be effective. |
| **Groundwater Recovery** | | |
| Groundwater Extraction | Yes | |
| Subsurface Drains | No | The fractured nature of the bedrock make this technology generally ineffective at this site. |
| **Discharge/Disposal** | | |
| - Publicly Owned Treatment Works | No | This technology will not be retained due to distance to connection with POTW. |

## Table 3-1

**REMEDIAL TECHNOLOGY SCREENING SUMMARY FOR GROUNDWATER**
**Navy Training Center - Site 1 (Landfill) and Site 2 (Fire Training Area)**

| GRA/Remedial Technology | Retain Technology | Comment |
|---|---|---|
| - Deep-Well Injection | No | Permitting problems and agency approval requirements and lack of data to substantiate that favorable geologic conditions exist makes this technology ineffective. |
| - Reinjection to Groundwater | No | Many potential problems and obstacles associated with this technology. |
| - Surface-Water Discharge | Yes | |
| **Institutional Controls** | Yes | |
| **No Action** | Yes | |

## Table 3-2

### REMEDIAL TECHNOLOGY SCREENING SUMMARY FOR SEDIMENT
### Navy Training Center - Landfill (Site 1) and Fire Training Area (Site 2)

| GRA/Remedial Technology | Retain Technology | Comment |
|---|---|---|
| **Removal** | | |
| Excavation | Yes | |
| Dredging | No | Site-specific conditions do not favor any of the various types of dredging. |
| **Containment** | No | Remediation activities would most likely damage shallow streams and permanently change the ecosystem. Also, limited long term effectiveness does not favor using this technology. |
| **On- and Off-site Treatment** | | |
| Thermal Destruction | No | Technology is applicable for organic contaminants at higher volumes than observed on-site. |
| **Physical/Chemical Treatment** | | |
| Thermal Desorption | No | Technology is applicable for organic contaminants at higher volumes than observed on-site. |
| Dechlorination Processes | No | Dechlorination Processes are not an applicable technology for metals contamination. |
| Soil Washing | Yes | More promising, cost effective handling of contaminated sediments is available. |
| Solvent Extraction | No | Small volumes do not justify the treatability studies and capital equipment costs associated with this technology. |
| Solidification/Stabilization | Yes | Only as part of off-site disposal requirements. |
| **Biological Treatment** | No | Biological treatment is not an applicable technology for metals contamination. |
| **In Situ Treatment** | | |

## Table 3-2

## REMEDIAL TECHNOLOGY SCREENING SUMMARY FOR SEDIMENT
### Navy Training Center - Landfill (Site 1) and Fire Training Area (Site 2)

| GRA/Remedial Technology | Retain Technology | Comment |
|---|---|---|
| In Situ Bioremediation | No | In Situ bioremediation is not an applicable technology for metals contamination. |
| In Situ Solidification/Stabilization | No | In Situ Solidification/Stabilization would permanently alter the hydraulics of the creeks and would make reestablishment of the ecosystem difficult. |
| **Disposal** | | |
| On-site Disposal | No | Small volume requiring disposal does not justify the cost associated with disturbing the existing landfill cap. |
| Off-site Disposal | Yes | |
| **Institutional Controls** | Yes | |
| **No Action** | Yes | |

# 4 Preliminary Alternative Development and Screening

## 4.1 Site 1 - Old Landfill

In this section, the remedial technologies retained from those evaluated in Section 3 have been assembled into comprehensive alternatives. The following alternatives were developed for Site 1 groundwater and sediments:

- Alternative 1: No Action;
- Alternative 2: Institutional Controls; and
- Alternative 3: Active Remediation/Treatment.

While many technologies were screened out in Section 3 due to effectiveness or implementability concerns, a small number of alternatives have been developed. The active remediation/ treatment technologies retained in Section 3 were looked at and, based on engineering judgement and experience, the most promising technologies, with respect to effectiveness, implementability, and cost, were chosen and assembled into Alternative 3. Because of the limited number of alternatives and because only one active remediation/ treatment alternative is developed, the number of alternatives will not be reduced prior to further evaluation in Section 5. Therefore, this section presents only descriptions of each of the assembled alternatives.

### 4.1.1 Alternative 1: No Action

The No Action alternative is presented as a basis of comparison for the other alternatives. This alternative involves no remedial action or environmental monitoring. It would leave contaminated sediments and groundwater in their present states. Development of this alternative is a requirement of the National Oil and Hazardous Substances Contingency Plan (NCP).

### 4.1.2 Alternative 2: Institutional Controls

Under this alternative, no direct action would be taken to remediate the VOCs and metals in the groundwater at Site 1. However, institutional controls that would limit exposure of humans to these contaminants would be implemented. Institutional controls could include access restrictions, regulatory restrictions on the construction and use of private wells, and well-use advisories.

Access restriction is an effective measure for limiting exposure to the public. At Site 1, it will be considered based on the fact the contamination is not deemed a serious threat to human health or the environment. Access restriction would be achieved through the use of deed restrictions combined with monitoring surface water, sediment, and groundwater on a semi-annual basis for two years. The results of the monitoring would be used to assure that there continues to be no serious threat to human health or the environment.

### 4.1.3 Alternative 3: Groundwater Extraction, Air Stripping, Precipitation/Coagulation/Flocculation, Sedimentation, and Sediment Excavation and Disposal

Under this alternative, groundwater would be collected by an extraction system of pumping wells. The groundwater from the seeps could either be extracted through shallow groundwater pumping wells or by subsurface drains. It is estimated that three wells pumping, with a combined rate of approximately 26 gallons per minute (gpm), would be necessary to capture the contaminated groundwater. The groundwater from the seeps would be extracted through wells rather than employing the use of subsurface drains because these wells already exist on site and because the use of subsurface drains would likely be less effective than extraction through wells for this site. The use of existing wells would also be more cost effective and more easily implemented than using subsurface drains because the seeps are close to the stream and the drain would have to be installed into bedrock. The current condition of the seeps and nearby sediments would be determined and reviewed initially to determine if collection of the seeps would be needed.

The extracted groundwater would be pretreated using precipitation/coagulation/flocculation to remove iron and manganese and to eliminate dissolved solids that may cause clogging or fouling of the air stripping unit. Following precipitation/ coagulation/flocculation, sedimentation would be employed as a second pretreatment step to remove solids and floc resulting from the precipitation/coagulation/flocculation process. The groundwater would then be treated using an air stripping unit to reduce TCE and VC concentrations. The treated groundwater would be regularly monitored until contaminant concentrations reach cleanup goals. An air permit may be required in order to discharge exhaust from the air stripper to the atmosphere. Finally, a NPDES or SPDES permit would be required to discharge the treated groundwater to the on-site creeks.

the on-site creeks.

Sediment would be excavated, then transported and disposed at an off-site TSD facility. Excavation of sediments in this area would require clearing and grubbing of areas surrounding the sediment to be excavated, construction of a decontamination pad for excavation equipment, and construction of a staging area for dewatering and temporary storage of excavated sediments. During removal of material, verification sampling would be used to ensure achievement of cleanup goals. After it has been confirmed that all contamination has been excavated, these areas would be backfilled with clean soil and properly restored. The excavated sediments would be hauled to a TSD facility permitted to accept the waste. Based on analytical data, lead was found at concentrations which may cause it to fail TCLP tests. In the event it does fail TCLP tests, treatment to meet characteristic-waste LDRs would be required prior to disposal.

During remediation of Site 1, temporary institutional controls, such as fencing and signs, would be employed in order to discourage humans from entering the area being remediated.

## 4.2 Site 2 - Fire Training Area

As with Site 1, screening of remedial technologies for Site 2 was based on engineering judgement. The remedial technologies for groundwater chosen from those evaluated in Section 3 and assembled into comprehensive alternatives include:

- Alternative 1: No Action;
- Alternative 2: Institutional Controls; and
- Alternative 3: Active Remediation/Treatment.

The alternatives selected for Site 2 were developed in the same way as alternatives for Site 1 (see Section 4.1).

After further consideration of sediments at this site, it was determined that because contaminated sediments were found in only one location (P2-SD-8) at concentrations only slightly above their respective cleanup goals, sediments would not be included in the Active Remediation/Treatment Alternative. The cost of remediating one sample location for contaminants just above cleanup goals cannot be justified because the analytical results are up to eight years old and the contaminant concentrations have, in all likelihood, been reduced over time through natural physical and biological processes. The Institutional Controls alternative will, however, include the contaminated sediment area in order to verify that sediment contamination is contained to one location, as well as to determine whether current contaminant concentrations have reached levels below the established cleanup goals.

### 4.2.1. Alternative 1: No Action

The No Action alternative is presented as a basis of comparison for the other alternatives. This alternative involves no remedial action or environmental monitoring and would leave contaminated groundwater in its present state. Development of this alternative is a requirement of the National Oil and Hazardous Substances Contingency Plan (NCP).

### 4.2.2. *Alternative 2: Institutional Controls*

Under this alternative, no direct action would be taken to remediate the metals in the groundwater at Site 2. However, institutional controls that would limit exposure of humans and ecological receptors to these contaminants would be implemented. Institutional controls could include access restrictions, regulatory restrictions on the construction and use of private wells, and well-use advisories.

Access restriction is an effective measure for limiting exposure to the public. At Site 2, it would be considered because the contamination is not deemed a serious threat to human health. Access restriction would be achieved through the use of deed restrictions combined with monitoring groundwater and sediment on a semi-annual basis for two years or longer, if deemed necessary by regulatory agencies and risk-based sediment monitoring. The results of the monitoring would be used to assure that there continues to be no serious threat to human health or the environment.

### 4.2.3 Alternative 3: Groundwater Extraction, Precipitation/Coagulation/Flocculation, and Sedimentation

Under this alternative, groundwater would be collected by a pumping well extraction system. It is estimated that two wells pumping at an approximate rate of 8 gallons per minute (gpm) would be necessary to capture the contaminated groundwater. The extracted groundwater would be pre-treated using precipitation/coagulation/flocculation to remove iron and manganese. Following precipitation/coagulation/flocculation, sedimentation would be employed to remove the resulting floc. A liquid-phase carbon adsorption unit would then be employed in order to treat PAHs. The treated groundwater would be regularly monitored until contaminant concentrations reach cleanup goals. Finally, a NPDES or SPDES permit would be required to discharge the treated groundwater to site streams/ditches that eventually discharge to the on-site stream/ditches.

During remediation of Site 2, as with Site 1, temporary institutional controls, such as fencing and signs, would be employed in order to discourage humans from entering the area of remediation.

# 5 Evaluation of Alternatives - Detailed Screening

This section presents a detailed evaluation of each alternative presented in Section 4. The alternatives are evaluated against seven criteria:

- Overall protection of human health and the environment,
- Compliance with ARARs,
- Long-term effectiveness and permanence,
- Reduction of toxicity, mobility, or volume,
- Short-term effectiveness,
- Implementability, and
- Cost.

A description of each of these criteria is presented below. In addition to evaluating the preceding seven criteria, two additional criteria are typically evaluated in the Record-of-Decision (ROD): state acceptance and community acceptance. These criteria address state and community concerns about the recommended alternative. These concerns are addressed after the FS is completed and prior to finalization of the ROD.

### Overall Protection of Human Health and the Environment

This criterion will provide a final check to assess whether an alternative provides adequate protection of human health and the environment. The overall assessment of protection draws on the assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

Evaluation of the overall protectiveness of an alternative will focus on whether a specific alternative achieves adequate protection, and how site risks posed through each pathway addressed by the FS are eliminated, reduced, or controlled through treatment, engineering, or institutional controls. This evaluation will allow for consideration of whether an alternative poses any unacceptable short-term or cross-media impacts to human health or the environment.

## Compliance with ARARs

**Definition of ARARs.** Section 121(d) of CERCLA requires that remedial actions attain federal or state environmental standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate (unless waiver of such compliance is justified). Federal ARARs may include requirements under federal environmental laws. State ARARs may only include promulgated, enforceable environmental or facility-siting laws that are more stringent or broader in scope than federal requirements. Because the State may give enforcement authority for delegated federal programs to local agencies that develop implementing regulations, some local regulations can also be ARARs.

An ARAR may be either "applicable" or "relevant and appropriate," but not both. If there is no specific federal or state ARAR for a particular chemical or remedial action, or if the existing ARARs are not considered sufficiently protective, then other criteria or guidelines "to be considered" (TBCs) may be identified and used to ensure the protection of public health and the environment. The definitions of "applicable," "relevant and appropriate," and "to be considered," drawn from the NCP, are presented below.

- Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.

- Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances found at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be relevant and appropriate.

- To Be Considereds (TBCs) are those advisories, criteria, or guidances developed by EPA, other federal agencies, or states that may be useful in developing CERCLA remedies. The TBC values and guidelines may be used as EPA deems appropriate.

Each of the alternatives will be evaluated for their effectiveness in meeting established ARARs or TBCs. The ability of the alternative to meet ARARs or TBCs will be a deciding factor on whether an alternative is maintained or screened out.

### Long-Term Effectiveness and Permanence

The evaluation of alternatives under this criterion addresses the expected results of the proposed remedial action in terms of the risk remaining at the facility after response objectives have been met. The primary focus of this evaluation is the extent and effectiveness of the controls that may be required to manage the remaining risk posed by treatment residuals and/or untreated wastes. All alternatives considered are subject to a review of effectiveness after five years.

### Reduction of Toxicity, Mobility, or Volume through Treatment

This criterion addresses the regulatory preference for selecting remedial actions that employ treatment technologies which permanently and significantly reduce the toxicity, mobility, or volume of the contaminants. This preference is satisfied when treatment is used to reduce the principal risks at a site through destruction of contaminants for a reduction of total mass of contaminants, to attain irreversible reduction in mobility of contaminants, or to achieve reduction of the total volume of contaminated media.

### Short-Term Effectiveness

This criterion addresses the impacts of an alternative during the construction and implementation phase until remedial response objectives are met. Under this criterion, alternatives are evaluated with respect to their effects on human health and the environment during implementation of the remedial action.

**Implementability**
The implementability criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation.

**Cost**
Detailed analysis of the selected remedial alternatives includes an estimation of the total cost of the alternative which includes the following steps:

- Estimation of capital, operations and maintenance (O & M), and institutional costs; and
- Present worth analysis.

The cost estimates were developed using standard engineering and remediation cost databases (RS Means Building Construction and Environmental Remediation Costs), bid prices for recent projects adjusted to 1999 dollars, typical unit prices charged by E&E, and engineering judgement.

Each section below provides a description of the alternative followed by criterion analyses. Following the individual analyses, the alternatives are compared and contrasted among each other. A preferred remedy is recommended in Section 6 based on this analysis and comparison.

## 5.1 Site 1 - Old Landfill

### 5.1.1 Alternative 1: No Action

#### 5.1.1.1 Alternative Description

This alternative provides no remedial response of VOCs and metals in the groundwater and sediments at Site 1 (Old Landfill). Contaminated sediments and groundwater would remain in their present states. Environmental monitoring would not be preformed. Development of this alternative is required by the NCP.

#### 5.1.1.2 Detailed Analysis

**Overall Protection of Human Health and the Environment**
This alternative provides no reduction in contaminant concentrations. Thus no reduction of risk to human health or ecological risks and bioaccumulation hazards. Under this alterna-

tive, contaminated groundwater would continue to migrate and sediment would migrate as particulate matter via erosion. There would be no added limits on receptor exposure or future use of contaminated media.

### Compliance with ARARs
There are no chemical-specific ARARs identified for sediments at the NTC sites. The established preliminary remediation goals (PRGs) for sediment would continue to be exceeded under this alternative. The chemical-specific ARARs identified for PRGs established for metals, would continue to be exceeded under this alternative. Because no active remediation would occur under this alternative, no action- or location-specific ARARs would apply.

### Long-Term Effectiveness and Permanence
As this alternative does nothing to reduce potential impacts on human health or meet sediment TBCs or groundwater ARARs, human and environmental risks would remain. This alternative is not effective in the long term and is not considered a permanent remedy.

### Reduction of Toxicity, Mobility, or Volume
Aside from naturally occurring reduction in contaminant concentrations expected over time, this alternative provides for no reduction in the toxicity, mobility or volume of contaminated groundwater or sediments.

### Short-Term Effectiveness
Since no remedial actions would be taken under this alternative, there would be no increase in adverse impacts to human health or the environment in the short term.

### Implementability
This no action alternative is readily implementable, as no construction or preparation activity is required. However, since this alternative would allow contaminants above cleanup goals to remain in the sediment and groundwater with no restrictions, regulating agencies may not consider this alternative feasible.

### Cost
Since the no action alternative does not involve any further activity or consideration, there would be no costs associated with this alternative.

### 5.1.2 Alternative 2: Institutional Controls

#### 5.1.2.1 Alternative Description

Contaminated sediments and groundwater would remain as they currently exist under this alternative. No direct action would be taken to remediate the contaminated sediments or groundwater. However, institutional controls would be implemented to limit human access and thus exposure to these contaminants. Such controls would include deed restrictions on new well construction and environmental monitoring.

Under Maryland Final Regulation, Chapter 07, Section 0.22 - Sanitary Landfills - Post-Closure Monitoring and Maintenance; landfills must be monitored for no less than five years after complete installation of the landfill cap. Since the cap was installed in 1994-1995, a semi-annual groundwater monitoring program for two-years would meet this requirement. Sampling to monitor the groundwater conditions at Site 1 would also satisfy Maryland regulations for landfill post-closure monitoring. Sampling would occur at wells 1-GW-1, 1-GW-3, 1-GW-5, 1-GW-6, 1-GW-7, 1-GW-8, 1-GW-9, 1-GW-10 and 1-GW-11. Samples would be analyzed for COPCs (chlorobenzene, chloroform, TCE, VC, antimony, iron and manganese). Well 1-GW-1 would serve as a background reading as it is located up-gradient of the landfill. Well 1-GW-11, located at the leading edge of the plume, would provide information pertaining to potential migration of the plume. At the end of the two-year monitoring program, results would be evaluated and future monitoring needs, if any, will be determined at that time.

Risk-based sediment and surface water sampling would also be performed during the monitoring program. The exact nature of the monitoring program will be determined after full evaluation of the pre-Record of Decision ( pre-ROD) sampling (April 1999) results has been completed. For purposes of the FS cost estimate, the monitoring program will consist of sampling select existing surface water and sediment locations once a year for two years. After the second year, the status of the surface water and sediment monitoring program will be re-evaluated. At the end of two years, monitoring could continue as during the first two years, monitoring could be discontinued, or monitoring could be increased to include activities such as a Rapid Bioassessment study. Sediment samples would be taken from known hot-spot areas. Samples would be analyzed for sediment COPCs (13 PAHs and 9 metals). Four surface water samples would be taken at prominent seep locations and analyzed for chemicals of concern (COCs) identified in the FS.

#### 5.1.2.2 Detailed Analysis

#### Overall Protection of Human Health and the Environment

This alternative provides for moderate protection of human health by restricting access to contamination, thereby reducing potential human exposure risk to the contaminants. Groundwater would continue to migrate and sediment would migrate as particulate matter via erosion (see Figures 2-1, and 2-5A for estimated extent of contamination). Although this alternative would limit human access and exposure to the contaminants present at this site, it would not limit access or exposure of ecological receptors to the contaminants or reduce ecological bioaccumulation hazards. It should be noted that the source of historical contamination has been remediated and continued improvement to both sediments and groundwater should be achieved over time.

#### Compliance with ARARs

There are no chemical-specific ARARs identified for sediments at Site 1. The developed PRGs for sediment would continue to be exceeded under this alternative, until source of contamination from the landfill was decreased over time due to the implementation of the interim remedial measure (landfill cap).

It is expected that the chemical-specific ARARs identified at Site 1, as well as the PRGs, would be met under this alternative. The cover installed on Site 1 reduces infiltration and will result in a subsequent decrease in contaminant loading resulting in groundwater meeting ARARs over time. Because no active remediation would occur under this alternative, no action- or location-specific ARARs would apply.

#### Long-Term Effectiveness and Permanence

The institutional controls incorporated in this alternative need to be maintained in order to successfully limit human access and exposure over the long term. Environmental risks would remain because this alternative does nothing to limit access or contaminant exposure to ecological receptors, nor does it meet sediment or groundwater PRGs until well into the future. Semi-annual environmental monitoring of groundwater, and annual monitoring of seeps and sediments over a two-year period would be performed. Results would be documented, as discussed in Section 5.1.2.1. A review of this alternative would be performed after two years from the start of the monitoring program to determine the effects of natural and biological processes. A report summarizing the conclusions of this review would determine if additional actions or further monitoring would be needed.

#### Reduction of Toxicity, Mobility, or Volume

Aside from naturally occurring reduction in contaminant concentration expected over time, this alternative provides for no reduction in the toxicity, mobility, or volume of sediment or groundwater contaminants. Institutional controls would serve to restrict human access to contamination and minimize direct contact.

#### Short-Term Effectiveness

No short-term impacts are expected to effect the environment during implementation of this alternative. There would be risks to workers during monitoring events. These risks can be effectively addressed by standard health and safety practices.

#### Implementability

This alternative is readily implementable. The services required for the institutional controls are readily available. No construction is required. Environmental monitoring is easily implemented. Administratively, the appropriate board or agency would need to approve land-use restrictions.

#### Cost

Although no remedial action would be performed under this alternative, semi-annual sampling of groundwater, and annual sampling of sediments and surface water would be conducted. The capital costs associated with this alternative, which include only deed restrictions, are estimated at $3,000. The annual O & M costs associated with sampling, analysis, and reports is estimated at $27,000. The two-year present worth of annual O & M costs is approximately $52,000 (see Table 5-1). The estimated total present worth of this alternative is $55,000.

### 5.1.3 Alternative 3: Groundwater Extraction, Air Stripping, Precipitation/Coagulation/Flocculation, Sedimentation; and Sediment Excavation and Disposal

#### 5.1.3.1 Alternative Description

Under this alternative, groundwater would be extracted through an extraction system consisting of three existing wells located at 1-GW-8, 1-GW-10, and 1-GW-11, pumping at rates of 14 gpm, 8 gpm, and 4 gpm, respectively, for a combined pumping rate of 26 gpm. Groundwater pumping rates and treatment periods for the contaminated aquifer are based on an estimated water balance and an assumed annual recharge rate of 8.6 inches. E&E estimates that five years would be required to treat the groundwater contaminants to cleanup goals.

Based on the limited existing data, the fractured bedrock/-overburden aquifer at the Bainbridge NTC cannot be adequately modeled at this time. Estimates completed for the FS are intended only to develop approximate costs. Actual flow rates, optimum number of wells, well locations, radius of capture, and actual cleanup time estimates would be determined during the remedial design phase.

The groundwater from the seeps would be controlled through the extraction of groundwater from wells 1-GW-8 and 1-GW-10 and possibly 1-GW-3. The current condition of the seeps and nearby sediments would be determined and reviewed initially to determine if collection of the seeps would be needed.

Groundwater would be pumped from the extraction wells to a treatment building which would provide the treatment system protection from the weather. The proposed treatment train would consist of: pre-treatment processes (precipitation/coagulation/-flocculation), a sedimentation unit (either a clarifier or sedimentation basin), and an air-stripping unit. System controls would also be located in this building.

After start-up of the groundwater extraction and treatment system, a groundwater monitoring program would be initiated. The program would monitor the progress of remediation, proper operation of the treatment system, and compliance with NPDES or SPDES discharge limits through sampling and analysis of the discharge effluent. An air permit may also be required for the air stripper. This would be investigated as part of the system design once more current data on groundwater contaminants is available.

Since a wastewater treatment system was previously used at the NTC, it is possible that there exists abandoned discharge piping leading to the Susquehanna River. This piping may be able to be used for discharge of water from the treatment system. Otherwise, the treated water would be discharged to the existing stream/ditch.

Sediment would be excavated, transported, and then disposed of at an off-site TSD facility.

Minor clearing and grubbing would be required prior to sediment excavation. This would involve clearing designated areas of vegetation and shrubs around the stream/ditch to make the excavation area accessible.

Approximately 230 cubic yards of contaminated sediments would be excavated from Site 1 streams/ditches in sections with the use of conventional earth-moving equipment such as backhoes and dump trucks and by hand excavation as necessary. The bottom and banks of the contaminated sections of the streams/ditches would be excavated to a depth of 0.5 feet. The area to be excavated is shown as estimated area of contamination on Figure 2-5. Expansion associated with the excavation of sediments is expected to account for approximately one-third of the original volume, bringing the total volume of excavated sediments to an estimated 310 cubic yards.

Excavated material would be placed on a designated staging area for temporary storage and dewatering prior to disposal. This staging area would be constructed of an impermeable liner, surface water controls, a leachate collection system, and an impermeable cover. Actual dewatering techniques would be evaluated during the remedial design phase, but could be as simple as allowing excess water to drain from the sediments placed in the temporary staging area or removing excess water with a filter press. The effluent from the dewatering process would be sent to the groundwater treatment system.

While the excavated sediments are being staged, verification sampling would be conducted to ensure achievement of cleanup goals. Samples of the sediment from the area being excavated would be collected and analyzed for the 13 PAHs and 9 metals of concern at Site 1 (aluminum, cadmium, chromium, copper, lead, manganese, mercury, nickel, and zinc). Excavation would be complete only after the verification sampling results indicate that the excavated area meets cleanup goals. In the event verification samples show that remaining concentrations are above cleanup goals, additional sediment would be excavated from that area and it would again be re-sampled until results confirmed cleanup goals were met. It should be noted that the cleanup goal for some analytes (cadmium, for example) is set at a level below typical instrument detection limits. Therefore, a measurement of "non-detect" using conventional analytical techniques, should be sufficient for evaluating compliance with cleanup goals. Because of the rocky nature and steepness of the streams/ditches, no backfilling of the stream bottom is proposed. This proposal action would be reviewed and verified during the design of this alternative. The area outside of the streams/ditches would be restored and re-vegetated.

Following the complete excavation of contaminated sediments, the excavation vehicles and equipment would be decontaminated. A decontamination pad would be constructed on site for this purpose. This pad would be curbed and gently sloped to allow drainage to a sump at one end. Liquids generated during decontamination activities would drain toward the sump. All fluids used in the decontamination procedure would be captured and properly treated and/or disposed.

The excavated sediments would be hauled to a permitted TSD facility capable of accepting the waste. Based on analytical data, lead was found at concentrations which may cause it to fail TCLP tests. In the event it does fail TCLP tests, treatment to meet characteristic waste LDRs would be required prior to disposal. The primary transport vehicle for transporting the excavated sediments to a TSD facility would be a 20-cubic-yard, lined dump-trailer with a tarpaulin cover. In addition, compliance with all state of Maryland and federal transportation regulations would need to be met.

During remediation of Site 1, temporary fencing would be constructed around the remedial area and signs discouraging access would be posted.

It is noted that based on pre-ROD sampling (April 1999), groundwater treatment and seep control may not be required, or only one of the treatment activities may be necessary. If seep control is necessary and groundwater treatment is not, this alternative will entail placement of recovery wells to control seeps. Because of the anticipated low volume of water collection necessary to control seeps, collected water would likely be stored on site and periodically shipped off site for treatment and disposal. If necessary this alternative would be modified in the future to address this situation.

### 5.1.3.2 Detailed Analysis

#### Overall Protection of Human Health and the Environment

This alternative would prevent continued migration of the groundwater contaminant plume, as well as contaminated groundwater seepage to surface water, and reduce groundwater contaminant concentrations through active remediation.

In removing the contaminated sediments from the streams/ditches, this alternative would provide adequate protection of environmental receptors from bioaccumulation hazards. Although potential sediment-related environmental risks would be reduced under this alternative, excavation would essentially destroy existing aquatic and benthic populations and habitat despite post-remediation efforts.

The temporary institutional controls, such as fencing and signs, around the area of remediation would serve to discourage humans from entering the area, thus reducing the potential for exposure to contaminants at this site during remediation.

### Compliance with ARARs

The groundwater extraction and treatment system would effectively bring groundwater contaminant concentrations below MCLs and PRGs. This treatment system would meet NPDES/ SPDES discharge limits for all extracted contaminants in the groundwater prior to discharge. Proper permits would be obtained prior to remediation.

No chemical-specific ARARs were identified for sediments at this site. However, the PRGs developed for the contaminated sediments at this site would be met. As previously detailed in Section 5.1.3.1, in the event sediment cleanup goals are set below typical instrument detection limits, a measurement of "non-detect" would be sufficient for evaluating cleanup goals. In the event sediments are found to be hazardous waste (i.e., metals fail TCLP tests), the excavated sediment would be transported to a RCRA-approved disposal facility for treatment prior to disposal. Otherwise, they may be disposed of at a TSD facility. The fluids used in decontamination procedures would be collected and either transported off-site for treatment and/or disposed at a TSD facility or treated by the proposed on-site groundwater treatment system.

No compliance issues are anticipated under this alternative with respect to location-specific ARARs.

### Long-Term Effectiveness and Permanence

The groundwater extraction and treatment system would actively treat contaminated groundwater until cleanup goals are met, providing a permanent remedy for groundwater contamination. Regular maintenance of the treatment system over the life of this alternative must be performed to ensure proper operation and effectiveness.

Excavation would permanently eliminate metal- and PAH-contaminated sediments from the streams/ditches at Site 1, and would therefore eliminate potential future effects on human and ecological health at the site. Through verification sampling, all contaminated sediment would be removed from the creeks. The contaminated sediments would be permanently treated and/or disposed off site.

A review to verify long-term effectiveness would be conducted at two years and again at five years after remediation is complete and would include groundwater, sediment, and surface water sampling, as well as a report summarizing the conclusions of the review.

### Reduction of Toxicity, Mobility, or Volume

This alternative would provide direct treatment of extracted contaminated groundwater thereby significantly reducing the toxicity of the contamination. The volume and mobility of the contaminated groundwater would also be reduced (more so than toxicity). The groundwater component of this alternative satisfies the statutory preference for using treatment technologies which will permanently and significantly reduce the toxicity, mobility, or volume of the contaminants; however, the sediment component of this alternative does not. Excavation will effectively and permanently remove the contaminants from the creeks at this site. Direct treatment of sediments would not be employed under this alternative, unless sediments are found to be hazardous and require treatment prior to disposal. Otherwise, the mobility of the contaminants would be limited through off-site disposal at a TSD facility.

### Short-Term Effectiveness

No adverse impacts during implementation are associated with the groundwater component. This alternative, as extracted contaminated groundwater, for the most part, remains in a closed treatment system until clean effluent is discharged. With proper engineering design and hydraulic modeling, contaminated groundwater would be effectively confined to the remediation area.

Short-term impacts associated with excavation and institutional controls which potentially could affect site workers and the near-by community, include temporary increases in dust production, noise disturbances, and truck traffic. Dust control, such as spraying water on the access area, could be implemented to reduce the generation of dust. Noise impacts and truck traffic could be mitigated, to some extent, through scheduling.

All temporary staged sediments would be covered during off-hours to discourage accidental human or wildlife exposure to the contaminants.

Excavation and handling of the excavated sediments would require protection of workers against dermal contact with these sediments. Off-site transport of contaminated sediments and decontamination fluids poses the potential for release of these materials at terminal points or en route.

Removing the contaminated sediments from the streams/ditches would essentially destroy existing aquatic and benthic populations and their habitats.

### Implementability

This alternative would be relatively easy to implement. Many vendors are available for the construction and operation of the groundwater extraction and treatment system. The treatment system would operate for five years and take seasonal fluctuations in groundwater into account. If monitoring results indicate that contaminant concentrations, through treatment, have fallen below cleanup goals before expected, the active remediation would be considered successful and complete at that time. Actual monitoring sampling procedures and protocols would be outlined as part of a sampling and analysis or quality control plan and the surface water discharge permit conditions. Discharge piping would be constructed to a nearby stream/ditch, unless piping from the previously used water treatment plant at the NTC could be used and connected to the treatment system. Regular maintenance of the groundwater extraction and treatment system would be required, as would continual monitoring to ensure NPDES/SPDES limits were being met.

The excavation component of this alternative would be relatively easy to implement as excavation contractors are locally available. Local contractors would also be utilized to construct the staging area and decontamination pad, as well as to clear and restore the site. The materials necessary to construct the staging area and decontamination pad are readily available and no construction or operational difficulties are expected. Stream/ditch flow would be diverted via shallow trenches and piping or hoses until remediation is complete. There are several laboratories available to analyze the verification and monitoring samples. For costing purposes, it was assumed that dewatering techniques will consist of allowing water to drain from the excavated sediments onto the staging area; however, actual dewatering techniques would be evaluated during the remedial design phase. Similarly, actual verification sampling procedures and protocols would be outlined as part of a sampling and analysis or quality control plan. Although 20-cubic yard, lined roll-offs would be used to transport the excavated sediments, the amount of sediment transported per trip would depend on weight restrictions.

Temporary institutional controls, including fencing and signs, are also expected to be implemented with no problems.

**Cost**

The remedial action to be performed under this alternative would include semi-annual sampling of groundwater, the posting of access-restriction signs in addition to installation of a groundwater treatment system and sediment removal. The capital costs associated with this alternative are estimated at \$320,000 (see Table 5-2). The annual O & M costs associated with this alternative is estimated at \$82,000 with the operation of the treatment plant accounting for approximately 70% of the total. The five-year present worth of annual O & M costs is estimated to be \$366,000. The estimated total present worth of this alternative is \$690,000.

## 5.2 Site 2 - Fire Training Area

### 5.2.1 Alternative 1: No Action

#### 5.2.1.1 Alternative Description

This alternative provides no remedial response to the presence of PAHs and metals in the groundwater at Site 2 (Fire Training Area). Contaminated groundwater would remain in its present state. Environmental monitoring would not be preformed. Development of this alternative is required by the NCP.

#### 5.2.1.2 Detailed Analysis

**Overall Protection of Human Health and The Environment**

This alternative provides no reduction in contaminant concentrations, thus no reduction of risks to human health and environment. Under this alternative, groundwater would continue to migrate southwest toward the Susquehanna River. There would also be no added limits on receptor exposure or future use of contaminanted media.

**Compliance with ARARs**

The chemical-specific ARARs identified for groundwater (MCL for benzo(a)pyrene) contamination at this site as well as the PRGs established for the remaining five PAHs and metals (iron and manganese) would continue to be exceeded under this alternative. Because no active remediation would occur under this alternative, no action- or location-specific ARARs would apply.

### Long-Term Effectiveness and Permanence

As this alternative does nothing to reduce potential impacts on human health or meet groundwater cleanup goals, human health risks would remain. This alternative is not effective in the long term and is not considered a permanent remedy.

### Reduction of Toxicity, Mobility, or Volume

Aside from naturally occurring reduction in contaminant concentrations expected over time, this alternative provides for no reduction in the toxicity, mobility or volume of contaminated groundwater.

### Short-Term Effectiveness

Since no remedial actions would be taken under this alternative, there would be no increase in adverse impacts to human health or the environment in the short term.

### Implementability

This no action alternative is readily implementable, as no construction or preparation activity is required. However, this alternative would allow contaminants above cleanup goals to remain in the groundwater.

### Cost

Since the no action alternative does not involve any further activity or consideration, there would be no costs associated with this alternative.

## 5.2.2 Alternative 2: Institutional Controls

### 5.2.2.1 Alternative Description

Groundwater contaminated with metals (iron and manganese) and six PAHs would remain as it currently exists under this alternative. No direct action would be taken to remediate the contaminated site groundwater. Institutional controls would be implemented to limit human access and thus exposure to these contaminants. Such controls would include deed restrictions on new well construction and posted signs at the Fire Training Area site. In addition, environmental monitoring would be performed under this alternative.

No specific monitoring requirements are listed under Maryland Final Regulations as they pertain to general sites. Therefore, a monitoring program similar to that established for Site 1 will be used. This will include a semi-annual monitoring program for two-years. Sampling should occur at wells 2-GW-1, 2-GW-3, 2-GW-5, and 2-GW-11. Samples would be tested for COPCs (iron, manganese, 1,1,2,2-PCA, chloroform and six PAHs). Well 2-GW-1 would serve as a background well as it is located up-gradient of the site and will provide a comparison to the other wells. Well 2-GW-5 is located down-gradient of the site and would provide information about the potential leading edge of the plume. At the end of the two-year monitoring program, results would be evaluated and future monitoring needs, if any, will be determined at that time.

Risk based sediment sampling would also be performed during the monitoring program. The exact nature of the monitoring program will be determined after full evaluation of the pre-ROD sampling (April 1999) results has been completed. For purposes of the FS cost estimate, the monitoring program will consist of sampling select existing surface water and sediment locations once a year for two years. After the second year, the status of the surface water and sediment monitoring program will be re-evaluated. At the end of two years, monitoring could continue as during the first two years, monitoring could be discontinued, or monitoring could be increased to include activities such as a Rapid Bioassessment study.

#### 5.2.2.2 Detailed Analysis

#### Overall Protection of Human Health and the Environment

This alternative provides for moderate protection of human health by restricting access to contamination, thereby reducing potential human exposure risk to the contaminants (see Figure 2-2 for estimated area of contamination). Under this alternative, groundwater would continue to migrate. Although this alternative would limit human access and exposure to the contaminants present at this site, it would not limit access or exposure of aquatic and benthic receptors to the contaminants.

#### *Compliance with ARARs*

It is expected that the cleanup goals identified for groundwater at the site would be met under this alternative. The source of contamination has been removed and the subsequent decreases in contaminant loading will result in the groundwater meeting ARARs over time. Because no active remediation would occur under this alternative, no-action- or location-specific ARARs would apply.

### Long-Term Effectiveness and Permanence

The institutional controls incorporated in this alternative need to be maintained in order to successfully limit human access and exposure over the long term. Environmental risks would remain because this alternative does nothing to limit access or contaminant exposure to ecological receptors, nor does it meet groundwater PRGs until well into the future. Semi-annual environmental monitoring over a two-year period would be performed, and results would be documented, as discussed in Section 5.2.2.1. A review of long-term effectiveness would be performed after two years from the start of the monitoring program to determine the effects of natural and biological processes. A report summarizing the conclusions of this review would determine if additional actions would be needed.

### Reduction of Toxicity, Mobility, or Volume

Aside from naturally occurring reduction in contaminant concentration expected over time, this alternative provides for no reduction in the toxicity, mobility, or volume of groundwater contaminants. Institutional controls would serve only to restrict human access to contamination present at the site and minimize direct contact.

### Short-Term Effectiveness

Other than short-term construction impacts associated with the placement of posted signs and risks to workers during monitoring, no other impacts are expected to effect human health or the environment during implementation of this alternative. Monitoring risks can be effectively addressed using standard health and safety practices. The duration of this alternative, prior to the two-year environmental monitoring component, is estimated at one month.

### Implementability

This alternative is readily implementable. The services and materials required for the institutional controls are readily available. Minor activity associated with posting of signs is required under this alternative and environmental monitoring is easily implemented. Administratively, the appropriate board or agency is required to approve land use restrictions.

### Cost

Although no remedial action would be taken under this alternative, semi-annual sampling of groundwater and annual sampling of sediment for two years would be conducted, as well as the posting of access restriction signs around the Fire Training Area. The capital cost associated with this alternative is estimated at $3,000 (see Table 5-3). The annual O & M cost associated with sampling, analysis, reports, data validation, and the maintenance of institutional controls is estimated at $14,000, with a two-year present worth of $27,000. The estimated total present worth of this alternative is $30,000.

## 5.2.3 Alternative 3: Groundwater Extraction,Precipitation/ Coagulation/Flocculation, and Sedimentation

### 5.2.3.1 Alternative Description

Under this alternative, groundwater would be extracted through an extraction system consisting of an existing well located at 2-GW-12 and one new well located near the former 2-GW-8 (location of historical PAH contamination), both pumping at a rate of 4 gpm (total combined rate of 8 gpm). It is estimated that a maximum of five years would be needed to treat the groundwater contaminants to cleanup goals. It should be noted that actual flow rates, optimum number of wells, well locations, and actual cleanup time estimates would be determined during the design phase, as these parameters determined for the FS are intended only to estimate the size of such a system and to develop approximate costs. Groundwater pumping rates and treatment periods for the contaminated aquifer are based on an estimated water balance and an assumed recharge rate of 8.6 inches per year.

Groundwater would be pumped from the extraction wells to a treatment building which would provide the treatment system protection from the weather. The treatment process would include pre-treatment processes (precipitation/coagulation/flocculation), a sedimentation unit (either a clarifier or sedimentation basin), a liquid-phase carbon adsorption unit (to remove PAHs), and system controls, all to be located in this building.

After start up of the groundwater extraction and treatment system, a groundwater monitoring program would be initiated. The program would monitor the progress of remediation, proper operation of the treatment system, and compliance with NPDES or SPDES discharge limits through sampling and analysis of the discharge effluent. In addition, monitoring of effluent from the carbon adsorption unit would indicate when the adsorption capacity of the carbon is beginning to be depleted, and thus indicate when the activated carbon needs to be regenerated or replaced. For strongly adsorbed contaminants, the cost of regeneration can be higher than replacement with new activated carbon.

Since a wastewater treatment system was previously used at the NTC, it is possible that there exists abandoned discharge piping leading to the Susquehanna River. This piping may be able to be used for discharge of water the treatment system proposed. Otherwise, the treated water would be discharged to the existing stream/ditch.

During remediation of Site 2, temporary fencing would be constructed around the remedial area and signs discouraging access would be posted.

#### 5.2.3.2 Detailed Analysis

##### Overall Protection of Human Health and the Environment

This alternative would prevent continued migration of the groundwater contaminant plume and reduce groundwater contaminant concentrations through active remediation. In addition, in the unlikely event that groundwater would be used as a drinking water source, this alternative would protect human health through hydraulic capture of the groundwater contaminant plume. The temporary institutional controls, such as fencing and signs, around the area of remediation would serve to discourage humans from entering the area, thus minimizing potential exposure to contaminants at this site during remediation.

##### Compliance with ARARs

The groundwater extraction and treatment system would effectively bring metal and PAH contaminant concentrations in ground water below MCLs or Human Health Risk Levels. This treatment system would meet NPDES/SPDES discharge limits for all extracted contaminants in the groundwater prior to discharge. No compliance issues are anticipated under this alternative with respect to action- or location-specific ARARs.

##### Long-Term Effectiveness and Permanence

The groundwater extraction and treatment system would actively treat contaminated groundwater until cleanup goals are met, providing a permanent remedy for groundwater contamination. No residual contamination is expected to remain following groundwater treatment under this alternative. Regular maintenance of the treatment system must be performed to ensure proper operation and effectiveness. A review to verify long-term effectiveness would be conducted two and five years after start up of the groundwater treatment system and would include groundwater sampling, as well as reports summarizing the conclusions of the reviews.

### Reduction of Toxicity, Mobility, or Volume

The groundwater component of this alternative satisfies the statutory preference for using treatment technologies that will permanently and significantly reduce the toxicity, mobility, or volume of the contaminants. It would provide direct treatment of extracted contaminated groundwater, thereby significantly reducing the toxicity of the contamination. The volume and mobility of the contaminated groundwater would also be reduced (more so than toxicity).

### Short-Term Effectiveness

No adverse impacts during implementation are associated with the groundwater component of this alternative, because extracted contaminated groundwater, for the most part, remains in a closed treatment system until clean effluent is discharged. With proper engineering design and hydraulic modeling, contaminated groundwater would be effectively confined to the remediation area. Short-term impacts associated with system construction, which potentially could affect site workers and the near-by community, include minor temporary increases in dust production, noise disturbances, and truck traffic. Dust control, such as spraying water on the access area, could be implemented to reduce the generation of dust. Noise impacts and truck traffic could be mitigated, to some extent, through scheduling.

### Implementability

This alternative would be relatively easy to implement. Many vendors are available for the construction and operation of the groundwater extraction and treatment system. The treatment system would operate for five years and take seasonal fluctuations in groundwater into account. If monitoring results indicate that contaminant concentrations have fallen below cleanup goals before expected, the active remediation would be considered successful and complete at that time. Actual monitoring and sampling procedures and protocols would be outlined as part of a sampling and analysis or quality control plan. Discharge piping would be constructed to a nearby stream/ditch, unless piping from the previously used water treatment plant at the NTC could be used and connected to the treatment system. Regular maintenance of the groundwater extraction and treatment system would be required, as would regular monitoring to ensure NPDES/SPDES limits were being met. Temporary institutional controls, including fencing and signs, are also expected to be implemented with no problems.

#### Cost

The remedial action to be performed under this alternative would include semi-annual sampling of groundwater and annual sampling of sediments, the posting of access-restriction signs in addition to the installation of a groundwater treatment system. The capital costs associated with this alternative are estimated at $210,000 (see Table 5-4). The annual O & M cost associated with this alternative is estimated at $65,000 with the operation of the treatment plant accounting for approximately two-thirds of the total. The five-year present worth of annual O & M costs is estimated to be $290,000. The estimated total present worth of this alternative is $500,000.

## 5.3 Comparison of Alternatives

The three alternatives developed for both Sites 1 and 2 are compared in this section with respect to each of the seven criteria. A summary of the evaluation is presented in Table 5-5.

### 5.3.1 Site 1 - Old Landfill

#### Overall Protection of Human Health and the Environment

Alternative 1 would do nothing to address the VOC and metals contamination in the groundwater or the metal and PAH contamination in the sediment. Therefore it would not protect human health and the environment. Alternative 2 would also leave the groundwater and sediment contaminants as they currently exist. However, human access would be restricted, reducing the potential exposure to these contaminants. Furthermore, environmental monitoring under Alternative 2 would track site conditions and contaminant concentration changes/reductions. Alternative 3, involving active remediation of the groundwater and sediment, would remove and treat contaminants, providing protection to human health and the environment. However, the potential negative impact to the riparian area caused by the sediment excavation equipment may do more harm to the ecological receptors and their habitat than the contamination itself. Furthermore, due to the considerable uncertainty associated with the Desktop ERA (whether the exposure concentrations are reflective of site conditions, the use of 5- to 8-year old analytical data, and whether down-gradient sediment concentrations have been reduced due to source removal by IRMs), environmental monitoring included under Alternative 2 may be a more appropriate initial action than active remediation.

### Compliance with ARARs

Groundwater and sediment ARARs and/or PRGs would continue to be exceeded under Alternative 1. Alternatives 2 and 3 would meet these ARARs and PRGs. In the event sediments fail TCLP tests, they would require treatment prior to disposal.

Because the chemical data used to establish cleanup goals for this site is 5- to 8-years old, contaminant concentrations may have diminished to levels below the proposed cleanup goals over time through natural physical and biological processes and as a result of the IRMs conducted in 1994-1995. Environmental monitoring, under Alternative 2, in order to gain current chemical characterization of the site, may be a more appropriate action than active remediation. Furthermore, collecting both filtered and unfiltered groundwater samples under Alternative 2 may better characterize the iron and manganese found in the groundwater at this site.

### Long-Term Effectiveness and Permanence

Alternative 1 does nothing to meet this evaluation criteria. A report summarizing the conclusions of environmental monitoring of groundwater, sediments, and surface water under Alternative 2 would be produced and, in the event that sufficient data are gathered showing reductions in contaminant concentrations below PRGs, less frequent monitoring may be conducted or may be ceased altogether. Through Alternative 3, contaminants would be permanently eliminated through active treatment of groundwater and excavation followed by off-site disposal of sediments. Regular maintenance of the groundwater treatment system under Alternative 3 is necessary in order to ensure proper operation and effectiveness. Two- and five-year reviews would be conducted under Alternatives 2 and 3 to assess their effectiveness.

### Reduction of Toxicity, Mobility, or Volume

As Alternatives 1 and 2 do not employ treatment technologies, CERCLA's preference of employing treatment in order to permanently and significantly reduce the toxicity, mobility, or volume of contaminants would not be met. The volume and mobility of contaminated groundwater would be reduced under Alternative 3. Alternative 3 also provides for direct treatment of extracted contaminated groundwater and will significantly reduce the toxicity of contamination in groundwater, thereby satisfying this statutory preference. However, contamination levels are based on 1991 and

1994 data. It is possible the contaminant concentrations have been reduced to levels below the established cleanup goals through natural physical and biological processes and/or through source removal via the IRMs, in which case, active remediation would not be necessary. Direct treatment of sediments will not be employed under Alternative 3, unless sediments are found to be hazardous through TCLP tests, in which case, these sediments would be treated prior to disposal.

### Short-Term Effectiveness

No short-term impacts are associated with Alternative 1, since no remedial action would take place. Under Alternative 2, short-term risks to workers during monitoring would be addressed by standard health and safety practices. Short-term construction related impacts associated with institutional controls (fencing), such as dust generation, minor noise disturbances, and truck traffic would be associated with Alternative 3; however, they can be reduced to some extent. Under Alternative 3, the staged sediments would be covered and site workers would wear personal protective clothing to prevent accidental exposure. Additionally, under Alternative 3, aquatic and benthic populations and their habitat would essentially be destroyed in areas of sediment excavation. The benefits of sediment removal must be carefully weighed against the damage caused to the riparian area through excavation. In addition, the actual need for sediment excavation may need to be re-evaluated through chemical and possibly biological characterization in order to gain an understanding of current conditions. Therefore, environmental monitoring under Alternative 2 may be a more appropriate action than active remediation.

### Implementability

As no construction or preparation activity is required under Alternative 1, this is a readily implementable alternative. No technical implementation problems are expected under Alternative 2 as services and materials are readily available for both the institutional controls and the monitoring components of this Alternative. Access and deed restrictions would require approval from the appropriate agency. Implementability obstacles to be handled under Alternative 3 include whether discharge piping could be tied into NTC's former water treatment system discharge piping, landfill stabilization, diversion of stream/ditch flow during remediation, and field tests that would be necessary to determine actual flow rates, number of wells, well locations, radius of capture, cleanup time, and other necessary parameters associated with the groundwater extraction and treatment system design.

### Cost

The estimated total present worth costs to implement the three Site 1 remedies presented in this FS are:

| | |
|---|---|
| • Alternative 1: No Action | $0 |
| • Alternative 2: Institutional Controls & Monitoring | $55,000 |
| • Alternative 3: Groundwater Treatment | $686,000 |

The estimated capital cost of Alternative 3 is $320,000. The proposed treatment system accounts for approximately 75% of this cost. A 15% contingency on capital costs was used for this alternative because of the limited data on recent groundwater contaminant concentrations and uncertainties associated with the design of a treatment system based on limited data.

Alternative 2 was estimated to have a 2-year monitoring period. The annual O & M cost of this alternative is $27,000. The 2-year present worth of the O & M costs is $55,000.

Alternative 3 was estimated to have a 5-year remedial period. Operation and maintenance of the proposed treatment plant are approximately 70% of the total annual O & M costs. The annual O & M cost of this alternative is $82,000. The 5-year present worth of the O & M costs is $366,000.

These costs are summarized on Table 5-6.

## 5.3.2 Site 2

### Overall Protection of Human Health and the Environment

Alternative 1 would do nothing to address the metals contamination in the groundwater. Therefore it would not protect human health. Alternative 2 would also leave the groundwater contaminants as they currently exist. However, access to groundwater would be restricted, reducing potential human exposure to these contaminants. Furthermore, environmental monitoring under this alternative would track site conditions and concentration changes/ reductions could be observed. Alternative 3, involving active remediation of the groundwater, would remove and treat contaminants, providing protection to human health from potential exposure.

### Compliance with ARARs

Groundwater PRGs would continue to be exceeded under Alternative 1. Alternatives 2 and 3 would meet these PRGs. Since the chemical data used to establish PRGs for this site is 5- to 8-years old, contaminant concentrations may have diminished to levels below the proposed cleanup goals over time through natural physical and biological processes or as a result of the IRMs conducted in 1994-1995. Environmental monitoring under Alternative 2, may be a more appropriate action than active remediation. Furthermore, collecting both filtered and unfiltered samples under Alternative 2 may better characterize the iron, manganese, and PAHs found in the groundwater at this site.

### Long-Term Effectiveness and Permanence

Alternative 1 does nothing to meet this evaluation criterion. A report summarizing the conclusions of environmental monitoring of groundwater under Alternative 2 would be produced. In the event that sufficient data are gathered showing reductions in contaminant concentrations below cleanup goals, less frequent monitoring may be conducted or may be ceased altogether. The effectiveness of Alternative 2 would be based on prevention of exposure and reduced contaminant loading as a result of source removal. Through Alternative 3, contaminants would be permanently eliminated through active treatment of groundwater. No residual contamination is expected to remain following active remediation under Alternative 3. Regular maintenance of the groundwater treatment system under Alternative 3 is necessary in order to ensure proper operation and effectiveness. Two- and five-year reviews would be conducted under Alternative 3 in order to ensure effectiveness of the alternative. Alternative 2 would also be reviewed after two years.

### Reduction of Toxicity, Mobility, or Volume

As Alternatives 1 and 2 do not employ treatment technologies, the CERCLA preference of employing treatment to permanently and significantly reduce the toxicity, mobility, or volume of contaminants is not met. The volume and mobility of contaminated groundwater would be reduced under Alternative 3. Alternative 3 provides for direct treatment of extracted contaminated groundwater and will reduce the toxicity of contamination in groundwater. However, contamination levels are based on 1991 and 1994 data. It is possible that the contaminant concentrations have been reduced to levels below the established cleanup goals through natural physical and biological processes and/or through source removal via the IRMs, in which case, active remediation would not be necessary.

### Short-Term Effectiveness

No short-term impacts are associated with Alternative 1, since no remedial action would take place. Under Alternative 2, short-term risks to workers during monitoring would be addressed by standard health and safety practices. Short-term impacts related to treatment system construction, such as dust generation, minor noise disturbances, and truck traffic would be associated with Alternative 3. However, these minor impacts can be reduced to some extent.

### Implementability

As no construction or preparation activity is required under Alternative 1, this is a readily implementable alternative. No technical implementation problems are expected under Alternative 2 as services and materials are readily available for both the institutional controls and the monitoring components of this Alternative. Groundwater use restrictions would require approval from the appropriate agency. Implementability obstacles to be handled under Alternative 3 include whether discharge piping could be tied into NTC's former water treatment system discharge piping and field tests that would be necessary to determine actual flow rates, number of wells, well locations, radius of capture, cleanup time, and other necessary parameters associated with the groundwater extraction and treatment system design.

### Cost

The estimated total present worth costs to implement the three remedies presented in this FS are:

- Alternative 1: No Action — $0
- Alternative 2: Institutional Controls & Monitoring — $30,000
- Alternative 3: Groundwater Treatment — $499,000

The estimated capital cost of Alternative 3 is $209,000. The proposed treatment system accounts for approximately 80% of this cost. A 15% contingency on capital costs was used for this alternative because of the limited data on recent groundwater contaminant concentrations and uncertainties associated with the design of a treatment system based on limited data.

Alternative 2 was estimated to have a 2-year remedial period. The annual O & M cost (consisting entirely sampling and analysis) of this alternative is $14,000. The 2-year present worth of the O & M costs is $27,000.

Alternative 3 was estimated to have a 5-year remedial period. Operation and maintenance of the proposed treatment plant are approximately two-thirds of the total annual O & M costs. The annual O & M cost of this alternative is $65,000. The 5-year present worth of the O & M costs is $290,000.

These costs are summarized on Table 5-6.

Table 5-1

REMEDIAL ACTION COST ANALYSIS
SITE 1 - OLD LANDFILL: ALTERNATIVE 2 - INSTITUTIONAL CONTROLS
FEASIBILITY STUDY
NAVY TRAINING CENTER BAINBRIDGE
PORT DEPOSIT, MARYLAND

| **Capital Costs** | | | | |
|---|---|---|---|---|
| **Item Description** | **Quantity** | **Unit** | **Cost/Unit** | **Cost *** |
| Deed Restrictions | 1 | each | $2,500 | $2,500 |
| *Total Direct Capital Costs* | | | | $2,500 |
| Contingency Allowance | 5% | | | $125 |
| **Total Capital Costs (rounded to the nearest $1,000)** | | | | **$3,000** |

| **Yearly Operation and Maintenance (O&M) Costs** | | | | |
|---|---|---|---|---|
| **Item Description** | **Quantity/Year** | **Unit** | **Cost/Unit** | **Cost** |
| Mob/Demob & Reports | 2 | event | $3,750 | $7,500 |
| Sediment & Surface Water Sampling & Analyses | 11 | sample | $410 | $4,510 |
| Groundwater Sampling & Analyses | 20 | sample | $366 | $7,317 |
| Subtotal O & M Costs | | | | $19,327 |
| Overhead and Profit | 15% | | | $2,899 |
| Administration | 5% | | | $966 |
| Subtotal O & M Costs | | | | $23,192 |
| Contingency Allowance | 15% | | | $3,479 |
| **Total O&M Costs (rounded to the nearest $1,000)** | | | | **$27,000** |

| **2-Year Cost Projection, Assumed Annual Discount Rate:** 6% | |
|---|---|
| Present Worth of 2 Years of O&M (rounded to nearest $1,000) | $52,000 |
| Total Capital Costs | $3,000 |
| **Total Alternative Cost (total capital cost plus present worth cost, rounded to nearest $1,000)** | **$55,000** |

Table 5-2

**REMEDIAL ACTION COST ANALYSIS**
**SITE 1 - OLD LANDFILL: ALTERNATIVE 3 - GROUNDWATER TREATMENT**
**FEASIBILITY STUDY**
**NAVY TRAINING CENTER BAINBRIDGE**
**PORT DEPOSIT, MARYLAND**

| **Capital Costs** | | | | |
|---|---|---|---|---|
| **Item Description** | **Quantity** | **Unit** | **Cost/Unit** | **Cost** |
| Mobilization and Demobilization | 1 | lump sum | $17,100 | $17,100 |
| Extraction Pumping System (25 gpm) | 1 | lump sum | $16,000 | $16,000 |
| Treatment Building & Control System | 1 | unit | $51,000 | $51,000 |
| Air Stripping Unit | 1 | unit | $12,000 | $12,000 |
| Pre-treatment Unit (precipitation/coagulation/flocculation) | 1 | unit | $42,000 | $42,000 |
| Sedimentation Unit (Clarifier) | 1 | unit | $20,000 | $20,000 |
| Startup | 1 | lump sum | $7,100 | $7,100 |
| Clear and grub sediment areas | 1.1 | acres | $161 | $183 |
| Excavate and dispose sediments | 310 | cu. yds. | $62 | $19,309 |
| Restoration | 1.3 | acres | $3,000 | $3,758 |
| *Total Direct Capital Costs (Rounded to Nearest $1,000)* | | | | $188,000 |
| **Indirect Capital Costs** | | | | |
| Survey & Stakeout | 1 | lump sum | $2,500 | $2,500 |
| Engineering and Design | 1 | lump sum | $40,000.00 | $40,000 |
| Legal Fees and License/Permit Costs | 5% | | | $9,400 |
| Contractor Reporting Requirements | 5% | | | $9,400 |
| Construction Oversight | 15% | | | $28,200 |
| *Total Indirect Capital Costs (Rounded to Nearest $1,000)* | | | | $90,000 |
| Subtotal Capital Costs | | | | $278,000 |
| Contingency Allowance | 15% | | | $41,700 |
| **Total Alternative Capital Cost (Rounded to the nearest $1000)** | | | | **$320,000** |

| **Yearly Operation and Maintenance (O&M) Costs** | | | | |
|---|---|---|---|---|
| **Item Description** | **Quantity/Year** | **Unit** | **Cost/Unit** | **Cost** |
| Mob/Demob & Reports | 2 | event | $3,750 | $7,500 |
| Sediment and Surface Water Sampling and Analyses | 5 | sample | $410 | $2,050 |
| Groundwater Sampling and Analyses | 20 | sample | $366 | $7,317 |
| Treatment Plant Operation | 1 | year | $41,600 | $41,600 |
| | | | | |
| | | | | |
| | | | | |
| Subtotal O & M costs | | | | $58,467 |
| Overhead and Profit | 15% | | | $8,770 |
| Administration | 5% | | | $2,923 |
| Insurance, Taxes, Licenses | 2.5% | | | $1,462 |
| Subtotal O & M costs | | | | $71,622 |
| Contingency Allowance | 15% | | | $10,743 |
| **Total O&M Costs (rounded to the nearest $1,000)** | | | | **$82,000** |

| **5-Year Cost Projection, Assumed Annual Discout Rate:** | 6% | |
|---|---|---|
| Present Worth of 5 years of O & M (rounded to nearest $1,000) | | $366,000 |
| Total Capital Costs | | $320,000 |
| **Total Alternative Cost (total capital cost plus present worth cost, rounded to nearest $1000)** | | **$686,000** |

Table 5-3

**REMEDIAL ACTION COST ANALYSIS**
**SITE 2 - FIRE TRAINING AREA: ALTERNATIVE 2 - INSTITUTIONAL CONTROLS**
**FEASIBILITY STUDY**
**NAVY TRAINING CENTER BAINBRIDGE**
**PORT DEPOSIT, MARYLAND**

| **Capital Costs** | | | | |
|---|---|---|---|---|
| **Item Description** | **Quantity** | **Unit** | **Cost/Unit** | **Cost** |
| Deed Restrictions | 1 | each | $2,500 | $2,500 |
| Subtotal Direct Capital Costs | | | | $2,500 |
| *Total Direct Capital Costs* | | | | $2,500 |
| Contingency Allowance | 5% | | | $125 |
| **Total Capital Costs (rounded to the nearest $1,000)** | | | | **$3,000** |
| | | | | |
| **Yearly Operation and Maintenance (O&M) Costs** | | | | |
| **Item Description** | **Quantity/Year** | **Unit** | **Cost/Unit** | **Cost** |
| Mob/Demob & Reports | 2 | event | $3,750 | $7,500 |
| Sediment Sampling and Analyses | 4 | sample | $410 | $1,640 |
| Groundwater Sampling and Analyses | 10 | sample | $228 | $2,279 |
| Subtotal O & M Costs | | | | $11,419 |
| Overhead and Profit | 15% | | | $1,713 |
| Subtotal O & M Costs | | | | $13,132 |
| Contingency Allowance | 5% | | | $657 |
| **Total O&M Costs (rounded to the nearest $1,000)** | | | | ***$14,000*** |

| **2-Year Cost Projection, Assumed Annual Discount Rate:** 6% | |
|---|---|
| Present Worth of 2 years of O & M (rounded to nearest $1,000) | $27,000 |
| Total Capital Costs | $3,000 |
| **Total Alternative Cost (total capital cost plus present worth cost, rounded to nearest $1,000)** | **$30,000** |

Table 5-4

**REMEDIAL ACTION COST ANALYSIS**
**SITE 2 - FIRE TRAINING AREA: ALTERNATIVE 3 - GROUNDWATER TREATMENT & SEDIMENT REMOVAL**
**FEASIBILITY STUDY**
**NAVY TRAINING CENTER BAINBRIDGE**
**PORT DEPOSIT, MARYLAND**

**Capital Costs**

| Item Description | Quantity | Unit | Cost/Unit | Cost |
|---|---|---|---|---|
| Mobilization and Demobilization | 1 | lump sum | $10,200 | $10,200 |
| Extraction Pumping System (8 gpm) | 1 | lump sum | $2,700 | $2,700 |
| Treatment Building & Control System | 1 | unit | $38,000 | $38,000 |
| Pre-treatment Unit (precipitation/coagulation/flocculation) | 1 | unit | $33,000 | $33,000 |
| Sedimentation Unit (Clarifier) | 1 | unit | $11,000 | $11,000 |
| Liquid-phase Carbon Unit | 1 | unit | $3,800 | $3,800 |
| Startup | 1 | lump sum | $4,200 | $4,200 |
| 7-foot galvanized chain-link fence | 250 | linear foot | $27 | $6,770 |
| Swing gate, 12-foot, double wide | 2 | each | $497 | $994 |
| Installation of Warning Signs | 6 | each | $49 | $293 |
| Clear and Grub Sediment Areas | 0.07 | acres | $161 | $12 |
| Excavate and Dispose Sediments (premium for small quantity | 10 | cu. yds. | $78 | $779 |
| Restoration | 0.08 | acres | $3,000 | $242 |
| *Total Direct Capital Costs (Rounded to Nearest $1,000)* | | | | $112,000 |
| **Indirect Capital Costs** | | | | |
| Survey & Stakeout | 1 | lump sum | $1,700 | $1,700 |
| Engineering and Design | 1 | lump sum | $40,000 | $40,000 |
| Legal Fees and License/Permit Costs | 5% | | | $5,600 |
| Contractor Reporting Requirements | 5% | | | $5,600 |
| Construction Oversight | 15% | | | $16,800 |
| *Total Indirect Capital Costs (Rounded to Nearest $1,000)* | | | | $70,000 |
| Subtotal Capital Costs | | | | $182,000 |
| Contingency Allowance | 15% | | | $27,300 |
| **Total Alternative Capital Cost (Rounded to the nearest $1000)** | | | | **$209,000** |

**Yearly Operation and Maintenance (O & M) Costs**

| Item Description | Quantity/Year | Unit | Cost/Unit | Cost |
|---|---|---|---|---|
| Mob/Demob & Reports | 2 | event | $3,750 | $7,500 |
| Sediment Sampling and Analyses | 4 | sample | $410 | $1,640 |
| Groundwater Sampling and Analyses | 10 | sample | $366 | $3,659 |
| Fence Repair/Gate Maintenance | 5% | year | $400 | $400 |
| Treatment Plant Operation | 1 | year | $33,000 | $33,000 |
| | | | | |
| Subtotal O & M Costs | | | | $46,199 |
| Overhead and Profit | 15% | | | $6,930 |
| Administration | 5% | | | $2,310 |
| Insurance, Taxes, Licenses | 2.5% | | | $1,155 |
| Subtotal O & M Costs | | | | $56,594 |
| Contingency Allowance | 15% | | | $8.489 |
| **Total O&M Costs (rounded to the nearest $1,000)** | | | | **$65,000** |

| **5-Year Cost Projection, Assumed Annual Discount Rate:** 6% | |
|---|---|
| Present Worth of 5 years of O & M (rounded to nearest $1,000) | $290,000 |
| Total Capital Costs | $209,000 |
| **Total Alternative Cost (total capital cost plus present worth cost, rounded to nearest $1000)** | **$499,000** |

Table 5-5

DETAILED ANALYSIS SUMMARY
NAVY TRAINING CENTER

| Criterion | Alternative 1<br>No Action | Alternative 2<br>Institutional Controls | Alternative 3<br>Active Remediation/Treatment |
|---|---|---|---|
| **Site 1 (Old Landfill)** | | | |
| Overall Protection of Human Health and the Environment | No protection of human health and environment. No reduction in contaminant concentrations or human health risks. Because of the age of the data and implemented IRMs, contaminant levels may already be below cleanup levels. | Moderate protection of human health. No protection of environment. No reduction in contaminant concentrations. Because of the age of the data and implemented IRMs, contaminant levels may already be below cleanup levels. | Protective of human health through reduction in contaminant concentrations. Protective of envilonmental receptors from bioaccumulation hazards. Removal of contaminated sediments from streams would effectively destroy current habitat and likely cause more damage than cleanup benefit. |
| Compliance with ARARs | Groundwater and sediment cleanup goals would continue to be exceeded. Because of the age of the data and implemented IRMs, contaminant levels may already be below cleanup levels. | Groundwater and sediment cleanup goals would continue to be exceeded. Because of the age of the data and implemented IRMs, contaminant levels may already be below cleanup levels. | Groundwater ARARs for VOCs and cleanup goals for metals would be met. Sediment cleanup goals for metals and PAHs would be met. |
| Long-Term Effectiveness and Permanence | Human and environmental risks would not be reduced. | Human risks would be reduced through access restrictions. Environmental risks would not be reduced. Institutional controls would need to be maintained over the long term. | No residual risks would remain under this alternative. Maintenance of the groundwater treatment system over the life of remediation is required to ensure effectiveness. |

Table 5-5

DETAILED ANALYSIS SUMMARY
NAVY TRAINING CENTER

| Criterion | Alternative 1<br>No Action | Alternative 2<br>Institutional Controls | Alternative 3<br>Active Remediation/Treatment |
|---|---|---|---|
| Reduction of Toxicity, Mobility, and Volume | Toxicity, mobility, and volume of contaminants would not be reduced aside from naturally occurring reduction. | Toxicity, mobility, and volume of contaminants would not be reduced aside from naturally occurring reduction. | Mobility and volume of groundwater contaminants would be reduced. Sediments would be disposed of off-site, thus removing contamination from the site. The groundwater component of this alternative satisfies the statutory preference for treatment. |
| Short-Term Effectiveness | No short-term impacts on human health or environment. | No short-term impacts on the environment. There would be risks to workers during monitoring, which would addressed with proper health and safety procedures. | Short-term impacts such as minor noise disturbances, truck traffic, and dust generation in the construction of the treatment system. Site workers to wear protective clothing. Staged sediments to be covered. |
| Implementability | Not applicable. | Technically and administratively implementable. | Minor implementation obstacles associated with discharge piping, landfill stabilization, stream/ditch flow diversion, and groundwater treatment field tests need to be addressed. |

Table 5-5

**DETAILED ANALYSIS SUMMARY**
**NAVY TRAINING CENTER**

| Criterion | Alternative 1<br>No Action | Alternative 2<br>Institutional Controls | Alternative 3<br>Active Remediation/Treatment |
|---|---|---|---|
| Cost | No costs associated with this alternative. | Capital: $3,000<br>Annual O & M: 27,000<br>Total Present Worth: $55,000 | Capital: $320,000<br>Annual O & M: $82,000<br>Total Present Worth: $686,000 |
| **Site 2 (Fire Training Area)** | | | |
| Overall Protection of Human Health and Environment | No protection of human health and environment. No reduction in contaminant concentrations or human health risks. Because of the implemented IRMs, contaminant shows decreasing trends on latest sampling (April 1999). | Moderate protection of human health. No protection of environment. Because of the implemented IRMs, contaminant shows decreasing trends on latest sampling (April 1999). | Protective of human health through reduction in contaminant concentrations. |
| Compliance with ARARs | Groundwater ARARs/PRGs would continue to be exceeded. | Over time ARARs wold be met through reduced contaminant loading to groundwater due to implementation of IRM (source removal). Because of the age of the data and implemented IRMs, contaminant levels. | Groundwater cleanup goals for metals and PAHs would be met. |

Table 5-5

DETAILED ANALYSIS SUMMARY
NAVY TRAINING CENTER

| Criterion | Alternative 1 No Action | Alternative 2 Institutional Controls | Alternative 3 Active Remediation/Treatment |
|---|---|---|---|
| Long-Term Effectiveness and Permanence | Human and environmental risks would not be reduced. | Human risks would be reduces through access restrictions and reduced loading to groundwater since IRM implemented. Environmental risks would not be reduced. Institutional controls would need to be maintained over the long term. | No residual risks would remain under this alternative. Maintenance of the groundwater treatment system over the life of remediation is required to ensure effectiveness. |
| Reduction of Toxicity, Mobility, and Volume | Toxicity, mobility, and volume of contaminants would not be reduced aside from naturally occurring reduction. | Toxicity, mobility, and volume of contaminants would not be reduced aside from naturally occurring reduction. | Mobility and Volume of groundwater contaminants would be reduced. This alternative satisfies the statutory preference for treatment. |
| Short-Term Effectiveness | No short-term impacts on human health or environment. | No short-term impacts on the environment. There would be risks to workers during monitoring which could be addressed with standard health and safety practices. | Short-term impacts such as minor noise disturbances, truck traffic, and dust generation in the construction of the treatment system. |
| Implementability | Not applicable. | Technically and administratively implementable. | Minor implementation obstacles associated with discharge piping and groundwater treatment field tests need to be addressed. |

| Table 5-5<br><br>**DETAILED ANALYSIS SUMMARY<br>NAVY TRAINING CENTER** | | | |
|---|---|---|---|
| **Criterion** | **Alternative 1<br>No Action** | **Alternative 2<br>Institutional Controls** | **Alternative 3<br>Active Remediation/Treatment** |
| Cost | No costs associated with this alternative. | Capital: $3,000<br>Annual O & M: $14,000<br>Total Present Worth: $30,000 | Capital: $209,000<br>Annual O & M: $65,000<br>Total Present Worth: $499,000 |

**Table 5-6**

**REMEDIAL ACTION COST ANALYSIS**
**SUMMARY OF ALTERNATIVE COSTS**
**FEASIBILITY STUDY**
**NAVY TRAINING CENTER BAINBRIDGE**
**PORT DEPOSIT, MARYLAND**

| ALTERNATIVE | COSTS | | | | |
|---|---|---|---|---|---|
| | Capital | Annual O&M | O&M Duration | O&M Present Worth | Total |
| Site 1 - Old Landfill | | | | | |
| Alternative 1 - No Action | $0 | $0 | 0 years | $0 | $0 |
| Alternative 2 - Institutional Controls & Monitoring | $3,000 | $27,000 | 2 years | $52,000 | $55,000 |
| Alternative 3 - Groundwater Treatment | $320,000 | $82,000 | 5 years | $366,000 | $686,000 |
| Site 2 - Fire Training Area | | | | | |
| Alternative 1 - No Action | $0 | $0 | 0 years | $0 | $0 |
| Alternative 2 - Institutional Controls & Monitoring | $3,000 | $14,000 | 2 years | $27,000 | $30,000 |
| Alternative 3 - Groundwater Treatment | $209,000 | $65,000 | 5 years | $290,000 | $499,000 |

# 6 Summary

## 6.1 General

Ecology & Environment, Inc. (E & E) was contracted by the Navy to perform a Remedial Investigation/Feasibility Study (RI/FS). This report addresses all components of the FS process.

- Section 1 provides a discussion of the site history and background. It also summarizes the results of the human health risk assessment and the desktop ecological risk assessment completed for Site1 and Site 2.
- Section 2 develops General Remedial Action Objectives (RAOs) for the two sites and medium-specific cleanup goals were established. This information was then used to identify the areas of each site to be addressed in later sections of the FS.
- Section 3 presents the identification and screening of appropriate remedial technologies.
- Section 4 presents the alternative development. This section took a focused approach to alternative development and presents only those alternatives believed to be most appropriate for the sites.
- Section 5 provides a detailed analysis and evaluation of the site alternatives developed in Section 4.
- Section 6 includes a summary and recommendations.

Based on the 1991/1994 sampling data and excluding areas remediated by previous IRMs, E & E concluded the groundwater chemicals of concern (COCs) at the Old Landfill site (Site 1) consisted of metals ( antimony, iron and manganese) and VOCs (chlorobenzene, chloroform, TCE, and VC). The sediment COCs consist of nine metals and 13 PAHs. The groundwater COCs at the Fire Training Area (Site 2) consisted of metals (iron and manganese) 1,1,2,2-PCA, chloroform and six PAHs. The sediment COCs for Site 2 consisted of four metals, cadmium, chromium, lead, and manganese.

Because sediments contaminated by metals at the Fire Training Area are isolated to one location and contaminant concentrations were only slightly above cleanup goals, remediation of the sediments is not deemed appropriate. Surface water contamination is dealt with indirectly because it is impractical to directly remediate surface water bodies, and the completed IRMs have reduced, and should continue to reduce, impacts to surface water.

For both sites, remedial action alternatives were developed and screened to three alternatives for detailed analysis. These three alternatives, for both sites, included:

- No Action;
- Institutional Controls; and
- Remediation/Treatment.

The three alternatives were evaluated based on seven criteria developed by the United States Environmental Protection Agency (USEPA):

- Overall protection of human health and the environment;
- Compliance with applicable or relevant and appropriate recommendations;
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility or volume;
- Short-term effectiveness;
- Implementability; and
- Cost.

## 6.2 Recommendations

The three alternatives developed for each site were compared with each of the seven USEPA criteria. Based on this comparison, the Institutional Controls alternative is recommended by E & E for both Sites 1 and 2. This recommendation is based on the following considerations:

- Considerable uncertainty associated with the Desktop Ecological Risk Assessment, which drives sediment preliminary remediation goals. Appendix E contains ecological risk management recommendations made by US Fish and Wildlife Service, who also developed the Desktop Ecological Risk Assessment. The recommendations presented are to gain a more accurate picture of existing site conditions through additional sampling;
- Many of the chemical data are up to eight years old - recent pre-ROD sampling indicates downward trends for groundwater, surface water, and sediment contaminants;
- Contaminant sources and migration pathways have been removed/reduced as a result of the IRMs, resulting in reduced contaminant concentrations in sediment and groundwater; and
- Likelihood that benthic and aquatic life and habitat would be

destroyed through sediment removal at Site1.

The Institutional Control alternative involves reducing human exposure to the contaminants by restricting the use of groundwater from the sites. Institutional Controls would be accomplished through deed restrictions on new well construction at both sites and intrusive activities at the landfill. An environmental monitoring program would also be performed semi-annually for two years. The monitoring program would record current site conditions including contaminant migration and concentration changes. This data would be used to evaluate the effect current concentrations of COCs may have on potential site receptors and to determine if additional actions are warranted.

The estimated total present-worth costs of the recommended alternatives are $55,000 at Site 1 and $30,000 at Site 2.

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# A

# Sediment Background Values

**Table A-1**

**BACKGROUND SEDIMENT CONCENTRATIONS (mg/kg)**

| | 8-SD-1 | 8-SD-2 DUP | P1-SD-3 2/91 | P1-SD-3 8/91 | P1-SD-3 2/91 | P1-SD-3 8/91 | Background Screening Concentration |
|---|---|---|---|---|---|---|---|
| Aluminum | 3940 | 4210 | 3190 | 2090 | 1380 | 1470 | 5193 |
| Antimony | 0.18U | 0.17U | 12U | 17.9 | 12U | 12U | 23.5 |
| Arsenic | 3 | 2 | 1 | 0.66 | 0.62 | 0.67 | 3.27 |
| Barium | 38.9 | 27.9 | 34.5 | 25.2 | 10.7 | 16 | 47.0 |
| Beryllium | 0.7 | 0.4 | 1U | 1U | 1U | 1U | 1.35 |
| Cadmium | 0.16 | 0.14 | 1U | 1U | 1U | 1U | 1.00 |
| Calcium | 2030 | 889 | 811 | 837 | 346 | 522 | 2085 |
| Chromium | 4.9 | 6.6 | 6.8 | 8.5 | 6 | 7.1 | 9.04 |
| Cobalt | 5.7 | 7.2 | 3.8 | 6.9 | 10U | 10.5 | 12.4 |
| Copper | 5.7 | 8.6 | 5.2 | 3.9 | 2.4 | 1.5 | 9.65 |
| Iron | 11900 | 12300 | 8490 | 5940 | 4470 | 27800 | 28676 |
| Lead | 15 | 18.7 | 14.3 | 4.7 | 3.6 | 14.1 | 24.0 |
| Magnesium | 1480 | 1670 | 2360 | 2290 | 1320 | 789 | 2849 |
| Manganese | 535 | 400 | 264 | 258 | 170 | 402 | 602 |
| Mercury | 0.02 | 0.02 | 0.04 | 0.04 | 0.04 | 0.04 | 0.054 |
| Nickel | 12.5 | 13.4 | 12.2 | 14.5 | 14.8 | 18.8 | 19.2 |
| Potassium | 620 | 495 | 1000 | 692 | 173 | 318 | 1134 |
| Sodium | 45.8 | 37 | 1000U | 50.7 | 1000U | 40.8 | 1350 |
| Vanadium | 20.2 | 18.1 | 12.6 | 10.3 | 5.5 | 8.7 | 23.8 |
| Zinc | 33.8 | 82.9 | 24.8 | 22.9 | 20.6 | 27.5 | 82.8 |
| Chlordane | 0.022U | 0.02U | 0.0017U | 0.0017U | 0.0017U | 0.0017U | 0.0281 |
| DDD | 0.0047 | 0.0037 | 0.0053 | 0.0033U | 0.002 | 0.0054 | 0.0067 |
| DDE | 0.013 | 0.0039 | 0.011 | 0.004 | 0.0024 | 0.0061 | 0.0153 |
| DDT | 0.027 | 0.0069 | 0.027 | 0.017 | 0.0098 | 0.0033U | 0.0356 |
| Acenaphthalene | 0.42U | 0.4U | 0.33U | 0.33U | 0.33U | 0.33U | 0.440 |
| Anthracene | 0.034 | 0.021U | 0.33U | 0.33U | 0.33U | 0.33U | 0.542 |
| Benzo(a)anthracene | 0.12 | 0.048 | 0.081 | 0.33U | 0.33U | 0.33U | 0.481 |
| Benzo(a)pyrene | 0.17 | 0.1 | 0.069 | 0.33U | 0.33U | 0.33U | 0.468 |
| Benzo(b)fluoranthene | 0.4 | 0.25 | 0.083 | 0.33U | 0.33U | 0.33U | 0.509 |
| Benzo(g,h,i)perylene | 0.098 | 0.057 | 0.07 | 0.33U | 0.33U | 0.33U | 0.483 |
| Benzo(k)fluoranthene | 0.091 | 0.042 | 0.07 | 0.33U | 0.33U | 0.33U | 0.488 |
| Chrysene | 0.17 | 0.08 | 0.085 | 0.33U | 0.33U | 0.33U | 0.468 |
| Fluoranthene | 0.23 | 0.088 | 0.15 | 0.33U | 0.33U | 0.33U | 0.454 |
| Fluorene | 0.042U | 0.04U | 0.33U | 0.33U | 0.33U | 0.33U | 0.532 |
| Indeno(1,2,3-cd)pyrene | 0.067 | 0.044 | 0.069 | 0.33U | 0.33U | 0.33U | 0.491 |
| Phenanthrene | 0.14 | 0.034 | 0.082 | 0.33U | 0.33U | 0.33U | 0.484 |
| Pyrene | 0.23 | 0.09 | 0.13 | 0.33 | 0.33U | 0.33U | 0.457 |

Background screening concentration = mean + 2 standard deviations. For each non-detect result (flagged U), the reported quantitation limit was used in the calculation.

# B

# Tables from the Human Health Risk Assessment of the Remedial Investigation Report

## B. Tables from the Human Health Risk Assessment of the Remedial Investigation Report.

The tables reproduced in Appendix B were generated as part of the Human Health Risk Assessment in the Remedial Investigation Report for Bainbridge Naval Training Center, Port Deposit, Maryland, February 1999, Ecology and Environment, Inc.

**Table 5-12**
**Exposure Point Concentrations for the Bainbridge Naval Training Center, Port Deposit, Maryland**

| Exposure Medium | Location | Chemical | Units | Number of Samples | Number of Detects | Expo. Point Conc. | Expo. Point Conc. Source |
|---|---|---|---|---|---|---|---|
| Sediment | Site 1: Old Landfill | Aluminum | mg/kg | 35 | 35 | 8.92E+03 | UCL - lognorm |
| | | Arsenic | mg/kg | 35 | 35 | 1.53E+00 | UCL - lognorm |
| | | Benzo[a]anthracene | mg/kg | 35 | 23 | 1.07E+00 | UCL - lognorm |
| | | Benzo[a]pyrene | mg/kg | 35 | 22 | 1.00E+00 | UCL - lognorm |
| | | Benzo[b]fluoranthene | mg/kg | 35 | 27 | 1.44E+00 | UCL - lognorm |
| | | Benzo[k]fluoranthene | mg/kg | 35 | 20 | 6.67E-01 | UCL - lognorm |
| | | Beryllium | mg/kg | 35 | 28 | 8.31E-01 | UCL - lognorm |
| | | Chlordane | mg/kg | 35 | 9 | 3.18E-02 | UCL - lognorm |
| | | Chromium(VI) | mg/kg | 35 | 35 | 1.68E+01 | UCL - lognorm |
| | | Chrysene | mg/kg | 35 | 24 | 1.13E+00 | UCL - lognorm |
| | | Dibenz[a,h]anthracene | mg/kg | 35 | 10 | 3.37E-01 | UCL - lognorm |
| | | Indeno[1,2,3-cd]pyrene | mg/kg | 35 | 22 | 7.92E-01 | UCL - lognorm |
| | | Iron | mg/kg | 35 | 35 | 2.85E+04 | UCL - lognorm |
| | | Manganese | mg/kg | 35 | 35 | 1.18E+03 | UCL - lognorm |
| | | Thallium | mg/kg | 35 | 2 | 1.06E+00 | UCL - lognorm |
| | | Vanadium | mg/kg | 35 | 35 | 2.64E+01 | UCL - lognorm |
| Tap Water | Site 1: Old Landfill | Antimony | mg/L | 66 | 1 | 3.01E-02 | UCL - lognorm |
| | | Arsenic | mg/L | 66 | 1 | 1.04E-03 | UCL - lognorm |
| | | Beryllium | mg/L | 17 | 17 | 2.59E-04 | UCL - lognorm |
| | | Cadmium | mg/L | 66 | 2 | 2.51E-03 | UCL - lognorm |
| | | Chlorobenzene | mg/L | 66 | 23 | 8.98E-02 | UCL - lognorm |
| | | Chloroform | mg/L | 4 | 4 | 4.00E-03 | Max Det |
| | | Chromium(VI) | mg/L | 66 | 17 | 7.65E-03 | UCL - lognorm |
| | | Di(2-ethylhexyl)phthalate | mg/L | 66 | 31 | 6.46E-03 | UCL - lognorm |
| | | Dichlorobenzene, 1,4- | mg/L | 66 | 23 | 9.41E-03 | UCL - lognorm |
| | | Dichloroethene, 1,2- (Mixed isomers) | mg/L | 66 | 52 | 1.35E-02 | UCL - lognorm |
| | | Dichloropropane, 1,2- | mg/L | 1 | 1 | 1.00E-03 | Max Det |
| | | Heptachlor | mg/L | 66 | 1 | 2.59E-05 | UCL - lognorm |
| | | Iron | mg/L | 66 | 66 | 2.45E+01 | UCL - lognorm |
| | | Manganese | mg/L | 66 | 66 | 6.97E+00 | Max Det |
| | | Methylene chloride | mg/L | 66 | 4 | 6.25E-03 | UCL - lognorm |
| | | Nickel, soluble salts | mg/L | 66 | 34 | 1.96E-02 | UCL - lognorm |
| | | Thallium | mg/L | 66 | 1 | 1.04E-03 | UCL - lognorm |
| | | Trichloroethene | mg/L | 66 | 37 | 6.40E-03 | UCL - lognorm |
| | | Vinyl chloride | mg/L | 26 | 2 | 6.62E-04 | UCL - lognorm |

*Note: The samples and chemical concentrations used in the calculation of exposure point concentrations are listed in Appendix I. Total Chromium reported in groundwater and sediment was assumed to be Chromium VI.

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**Table 5-13**

**Exposure Point Concentrations for the Bainbridge Naval Training Center, Port Deposit, Maryland**

| Exposure Medium | Location | Chemical | Units | Number of Samples | Number of Detects | Expo. Point Conc. | Expo. Point Conc. Source |
|---|---|---|---|---|---|---|---|
| Sediment | Site 2: Fire Trng. Area | Arsenic | mg/kg | 5 | 5 | 8.30E-01 | Max Det |
| | | Beryllium | mg/kg | 3 | 3 | 3.80E-01 | Max Det |
| | | Iron | mg/kg | 5 | 5 | 8.07E+03 | Max Det |
| | | Manganese | mg/kg | 5 | 5 | 4.77E+02 | Max Det |
| Soil | Site 2: Fire Trng. Area | Aluminum | mg/kg | 7 | 7 | 1.45E+04 | UCL - lognorm |
| | | Arsenic | mg/kg | 7 | 2 | 8.15E-01 | UCL - lognorm |
| | | Iron | mg/kg | 7 | 7 | 1.77E+04 | Max Det |
| | | Manganese | mg/kg | 7 | 7 | 5.44E+02 | UCL - lognorm |
| Tap Water | Site 2: Fire Trng. Area | Aldrin | mg/L | 54 | 1 | 2.75E-05 | UCL - lognorm |
| | | Aluminum | mg/L | 54 | 54 | 1.50E+00 | UCL - lognorm |
| | | Arsenic | mg/L | 54 | 6 | 1.13E-03 | UCL - lognorm |
| | | Benzo[a]anthracene | mg/L | 1 | 1 | 1.00E-03 | Max Det |
| | | Benzo[a]pyrene | mg/L | 2 | 2 | 2.00E-03 | Max Det |
| | | Benzo[b]fluoranthene | mg/L | 2 | 2 | 3.00E-03 | Max Det |
| | | Benzo[k]fluoranthene | mg/L | 1 | 1 | 2.00E-03 | Max Det |
| | | Beryllium | mg/L | 54 | 8 | 3.10E-03 | UCL - lognorm |
| | | Cadmium | mg/L | 54 | 3 | 2.66E-03 | UCL - lognorm |
| | | Chloroform | mg/L | 54 | 2 | 5.64E-03 | UCL - lognorm |
| | | Chromium(VI) | mg/L | 54 | 19 | 7.57E-03 | UCL - lognorm |
| | | Chrysene | mg/L | 2 | 2 | 2.00E-03 | Max Det |
| | | Di(2-ethylhexyl)phthalate | mg/L | 54 | 18 | 6.39E-03 | UCL - lognorm |
| | | Dichlorobenzene, 1,4- | mg/L | 1 | 1 | 1.00E-03 | Max Det |
| | | Indeno[1,2,3-cd]pyrene | mg/L | 2 | 2 | 2.00E-03 | Max Det |
| | | Iron | mg/L | 54 | 54 | 7.92E+01 | Max Det |
| | | Manganese | mg/L | 54 | 54 | 5.50E+00 | Max Det |
| | | Methylene chloride | mg/L | 54 | 5 | 7.98E-03 | UCL - lognorm |
| | | Tetrachloroethane, 1,1,2,2- | mg/L | 54 | 6 | 5.25E-03 | UCL - lognorm |
| | | Thallium | mg/L | 54 | 2 | 1.00E-03 | UCL - lognorm |
| | | Trichloroethene | mg/L | 6 | 6 | 1.97E-03 | UCL - lognorm |
| | | Zinc | mg/L | 54 | 51 | 2.41E-01 | UCL - lognorm |

*Note: The samples and chemical concentrations used in the calculation of exposure point concentrations are listed in Appendix I. Total Chromium reported in groundwater and sediment was assumed to be Chromium VI.

**Table 5-14**

**RECREATIONAL SEDIMENT EXPOSURE:**
**PATHWAY 1A - INCIDENTAL INGESTION OF CHEMICALS IN SEDIMENT**
**ADOLESCENT**

Equation:

$$Intake\ (mg/kg\text{-}day) = \frac{CS \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

where:

- CS = Chemical Concentration in Sediment (mg/kg)
- IR = Ingestion Rate (mg/day)
- CF = Conversion Factor ($10^{-6}$ kg/mg)
- FI = Fraction Ingested from Contaminated Source (unitless)
- EF = Exposure Frequency (day/years)
- ED = Exposure Duration (years)
- BW = Body Weight (kg)
- AT = Averaging Time (period over which exposure is averaged, in days)

| Variable | Case | Value (Rationale/Source) |
|---|---|---|
| CS | RME | UCL or maximum observed concentration in stream sediment |
| IR | RME | 100 mg/day (default value for adults; EPA 1991b) |
| FI | RME | 0.5 (professional judgment) |
| EF | RME | 50 days/year (professional judgment) |
| ED | RME | 10 years (professional judgment) |
| BW | RME | 42 kg (median body weight for age group 6-16; EPA 1989b) |
| AT | RME | Pathway specific period of exposure for noncarcinogenic effects (i.e., ED x 365 days/year), and 70-year lifetime for carcinogenic effects (i.e., 70 years x 365 days/year) (EPA 1989a) |

Key:

RME = Reasonable maximum exposure.
UCL = 95% upper confidence limit of the mean.

## Table 5-15

## RECREATIONAL SEDIMENT EXPOSURE: PATHWAY 1B - DERMAL CONTACT WITH CHEMICALS IN SEDIMENT ADOLESCENT

Equation:

$$\textit{Absorbed Dose (mg/kg-day)} = \frac{CS \times ABS \times CF \times SA \times AF \times FC \times EF \times ED}{BW \times AT}$$

where:

CS = Chemical Concentration in Soil (mg/kg)
ABS = Absorption Factor (Unitless)
CF = Conversion Factor ($10^{-6}$ mg/kg)
SA = Skin Surface Area Available for Contact ($cm^2$/event)
AF = Soil to Skin Adherence Factor (mg/$cm^2$)
FC = Fraction of contacted soil/sediment from contaminated area (Unitless)
EF = Exposure Frequency (events/year)
ED = Exposure Duration (years)
BW = Body Weight (kg)
AT = Averaging Time (period over which exposure is averaged, in days)

| Variable | Case | Value (Rationale/Source) |
|---|---|---|
| CS | RME | UCL or maximum observed concentration in site sediment. |
| ABS | RME | 3.2% for arsenic, 1% for other metals, 10% for pesticides and semivolatile organic compounds (EPA 1995f) |
| SA | RME | 3,100 $cm^2$ (25% of median total body surface area for age group 6-16; EPA 1992c) |
| AF | RME | 1.0 mg/$cm^2$ (EPA 1992c) |
| FC | RME | 0.5 (professional judgment) |
| EF | RME | 50 days/year (professional judgment) |
| ED | RME | 10 years (professional judgment) |
| BW | RME | 42 kg (median body weight for age group 6-16; EPA 1989b) |
| AT | RME | Pathway-specific period of exposure for noncarcinogenic effects (i.e., ED x 365 days/year), and 70-year lifetime for carcinogenic effects (i.e., 70 years x 365 days/year) (EPA 1989a) |

Key:

RME = Reasonable maximum exposure.
UCL = 95% upper confidence limit of the mean.

**Table 5-16**

**RESIDENTIAL SOIL EXPOSURE:**
**PATHWAYS 2A - INCIDENTAL INGESTION OF CHEMICALS IN SOIL**
**ADULT (AGE-INTEGRATED) AND CHILD**

Equation for chemical contaminants:

$$Age\text{-}Integrated\ intake\ (mg/kg\text{-}day) = \frac{CS \times CF}{AT} \times \left[\frac{IRc \times EDc \times EFc}{BWc} + \frac{IRa \times EDa \times EFa}{BWa}\right]$$

$$Child\ intake\ (mg/kg\text{-}day) = \frac{CS \times CF \times IRc \times EDc \times EFc}{AT \times BWc}$$

Where:

CS = Contaminant Concentration in Soil (mg/kg)
CF = Conversion Factor ($10^{-6}$ kg/mg)
IRc = Ingestion Rate for Soil, child ages 1-6 (mg/day)
IRa = Ingestion Rate for Soil, adult (mg/day)
EDc = Exposure Duration, child ages 1-6 (years)
EDa = Exposure Duration, adult (years)
EFc = Exposure Frequency, child (days/year)
EFa = Exposure Frequency, adult (days/year)
BWc = Body Weight, child ages 1-6 (kg)
BWa = Body Weight, adult (kg)
AT = Averaging Time (period over which exposure is averaged - days)

| Variable | Case | Value (Rationale/Source) |
|---|---|---|
| CS | RME/CT | UCL or maximum observed concentration in soil at Fire Training Area |
| IRc | RME | 200 mg/day (default value for children; EPA 1991b) |
| IRa | RME | 100 mg/day (default value for adults; EPA 1991b) |
| EDc | RME | 6 years (entire duration of age group; EPA 1991b) |
| EDa | RME | 24 years (adult portion of 90th percentile time living at one residence; EPA 1991b) |
| EFc | RME | 350 days/year (EPA 1991b) |
| EFa | RME | 350 days/year (EPA 1991b) |
| BWc | RME | 15 kg (child average; EPA 1991b) |
| BWa | RME | 70 kg (adult average; EPA 1991b) |
| AT | RME | Pathway-specific period of exposure for noncarcinogenic effects (i.e., ED x 365 days/year), and 70-year lifetime for carcinogenic effects (i.e., 70 years x 365 days/year) (EPA 1989a) |

Key:

RME = Reasonable maximum exposure.
UCL = 95% upper confidence limit of the mean.

## Table 5-17

## RESIDENTIAL SOIL EXPOSURE: PATHWAYS 2B - DERMAL CONTACT WITH CHEMICALS IN SOIL ADULT (AGE-INTEGRATED) AND CHILD

Equation for chemical contaminants:

$$\text{Age-Integrated absorbed dose (mg/kg-day)} = \frac{CS \ X \ AF \ x \ ABS \ x \ CF}{AT} \ x \left[\frac{SAc \ x \ EDc \ x \ EFc}{BWc} + \frac{SAa \ x \ EDa \ x \ EFa}{BWa}\right]$$

$$\text{Child absorbed dose (mg/kg-day)} = \frac{CS \ x \ AF \ x \ ABS \ x \ CF \ x \ SAc \ x \ EDc \ x \ EFc}{AT \ x \ BWc}$$

Where:

CS = Contaminant Concentration in Soil (mg/kg)
AF = Soil to skin adherence factor ($mg/cm^2$)
ABS = Absorption Factor (unitless)
CF = Conversion Factor ($10^{-6}$ kg/mg)
SAc = Skin surface area available for contact, child ages 1-6 ($cm^2$/day)
SAa = Skin surface area available for contact, adult ($cm^2$/day)
EDc = Exposure Duration, child ages 1-6 (years)
EDa = Exposure Duration, adult (years)
EFc = Exposure Frequency, child (days/year)
EFa = Exposure Frequency, adult (days/year)
BWc = Body Weight, child ages 1-6 (kg)
BWa = Body Weight, adult (kg)
AT = Averaging Time (period over which exposure is averaged - days)

| Variable | Case | Value (Rationale/Source) |
|---|---|---|
| CS | RME | UCL or maximum observed concentration in soil at Fire Training Area |
| AF | RME | 1.0 $mg/cm^2$ (EPA 1992c) |
| ABS | RME | 3.2% for arsenic, 1% for other metals, 10% for pesticides and semivolatile organic compounds (EPA 1995f) |
| SAc | RME | 2,000 $cm^2$ (30% of median body area of children 3-4 years old; EPA 1992c) |
| SAa | RME | 5,000 $cm^2$ (25% of median adult body surface area; EPA 1992c) |
| EDc | RME | 6 years (entire duration of age group; EPA 1991b) |
| EDa | RME | 24 years (adult portion of 90th percentile time living at one residence; EPA 1991b) |
| EFc | RME | 350 days/year (EPA 1991b) |
| EFa | RME | 350 days/year (EPA 1991b) |
| BWc | RME | 15 kg (child average; EPA 1991b) |
| BWa | RME | 70 kg (adult average; EPA 1991b) |
| AT | RME | Pathway-specific period of exposure for noncarcinogenic effects (i.e., ED x 365 days/year), and 70-year lifetime for carcinogenic effects (i.e., 70 years x 365 days/year) (EPA 1989a) |

Key:

RME = Reasonable maximum exposure.
UCL = 95% upper confidence limit of the mean.

## Table 5-18

## FUTURE RESIDENTIAL WATER USAGE: PATHWAY 3A - INGESTION OF CHEMICALS IN DRINKING WATER (AND BEVERAGES MADE USING DRINKING WATER) ADULTS AND CHILDREN

Equation:

$$Intake\ (mg/kg\text{-}day) = \frac{CW \times IR \times EF \times ED}{BW \times AT}$$

where:

CW = Chemical concentration in water (mg/L)
IR = Ingestion rate (L/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged, in days)

| Variable | Case | Receptor | Value (Rationale/Source) |
|---|---|---|---|
| CW | RME | Adult/Child | UCL or maximum concentrations in groundwater |
| IR | RME | Adult<br>Child | 2 L/day (90th percentile; EPA 1991b)<br>1L/day (EPA 1989b) |
| EF | RME | Adult/Child | 350 days/year (EPA 1991b) |
| ED | RME | Adult<br>Child | 30 years (90th percentile living time at one residence; EPA 1991b)<br>6 years (entire duration of age, group (EPA 1991b) |
| BW | RME | Adult<br>Child | 70 kg (adult average; EPA 1991b)<br>15 kg (EPA 1991b) |
| AT | RME | Adult/Child | Pathway-specific period of exposure for noncarcinogenic effects (i.e., ED x 365 days/year), and 70-year lifetime for carcinogenic effects (i.e., 70 years x 365 days/year) (EPA 1989a) |

Key:

RME = Reasonable maximum exposure.
UCL = 95% confidence limit of the mean.

**Table 5-19**

**FUTURE RESIDENTIAL WATER USAGE:**
**PATHWAY 3B - DERMAL CONTACT**
**WITH CHEMICALS DURING SHOWERING OR BATHING**
**ADULTS AND CHILDREN**

Equation:

$$Absorbed\ dose\ (mg/kg\text{-}day) = \frac{DA \times SA \times EF \times ED}{BW \times AT}$$

where:

DA = Dose absorbed per unit area per event ($mg/cm^2$-event)
SA = Skin surface area available for contact ($cm^2$)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged, in days)

| Variable | Case | Receptor | Value (Rationale/Source) |
|---|---|---|---|
| DA | RME | Adult/Child | Chemical-specific values used (calculation presented in Appendix J, assumed 15 minute exposure time; EPA 1992c) |
| SA | RME | Adult<br>Child | 20,000 $cm^2$ (total body median SA for adult males; EPA 1992c)<br>6,600 $cm^2$ (total body median SA for children 3-4 years old; EPA 1992c) |
| EF | RME | Adult/Child | 350 days/year (EPA 1991b) |
| ED | RME | Adult<br>Child | 30 years (90th percentile time living at one residence; EPA 1991b)<br>6 years (entire duration of age group (EPA 1991b) |
| BW | RME | Adult<br>Child | 70 kg (adult average; EPA 1991b)<br>15 kg (EPA 1991b) |
| AT | RME | Adult/Child | Pathway-specific period of exposure for noncarcinogenic effects (i.e., ED x 365 days/year), and 70-year lifetime for carcinogenic effects (i.e., 70 years x 365 days/year) (EPA 1989a) |

Key:

RME = Reasonable maximum exposure.
UCL = Upper 95 percent confidence limit on the arithmetic average.

**Table 5-20**

**FUTURE RESIDENTIAL WATER USAGE:**
**PATHWAY 3C - INHALATION OF AIRBORNE (VAPOR PHASE) CHEMICALS**
**ADULTS**

Equation:

$$Intake\ (mg/kg\text{-}day) = \frac{E_{inh} \times EF \times ED}{AT}$$

where:

$E_{inh}$ = Inhalation exposure per shower (mg/kg-event)
EF = Exposure frequency (events/year)
ED = Exposure duration (years)
AT = Averaging time (period over which exposure is averaged, in days)

| Variable | Case | Value (Rationale/Source) |
|---|---|---|
| $E_{inh}$ | RME | Values modeled from VOC concentrations in groundwater using model from Foster and Chrostowski (1987) (see Appendix K) |
| EF | RME | 350 days/year (EPA 1991b) |
| ED | RME | 30 years (90th percentile time living at one residence; EPA 1991c) |
| AT | RME | Pathway-specific period of exposure for noncarcinogenic effects (i.e., ED x 365 days/year), and 70-year lifetime for carcinogenic effects (i.e., 70 years x 365 days/year) (EPA 1989a) |

Key:

RME = Reasonable maximum exposure.
UCL = 95% upper confidence limit of the mean.

**Table 5-21**

**WEIGHT-OF-EVIDENCE
CATEGORIES FOR CHEMICAL CARCINOGENICITY
HUMAN HEALTH RISK ASSESSMENT**

| Group | Description |
|---|---|
| A | Human Carcinogen |
| B | Probable Human Carcinogen:<br>B1: Limited human data are available.<br>B2: Sufficient evidence in animals or no evidence in humans. |
| C | Possible Human Carcinogen |
| D | Not Classifiable |
| E | Evidence of Noncarcinogenicity for Humans |

*Source: United States Environmental Protection Agency 1986.*

# Table 5-22
## Toxicity Indices for Carcinogenic Effects of COPCs at the Bainbridge Naval Training Center, Port Deposit, Maryland

| Chemical | Carcinogen Class | Exposure Route | Slope Factor (mg/kg-day)$^{-1}$ | Target Organ | Tumor Type | Basis Species | Basis Exposure Route | Reference Source |
|---|---|---|---|---|---|---|---|---|
| Aldrin | B2 | Inhalation | 1.7E+01 | Liver | liver carcinoma | mouse/C3H (Davis); mouse/B6C3F1, male (NCI) | diet | IRIS |
| | | Oral | 1.7E+01 | Liver | liver carcinoma | mouse/C3H (Davis); mouse/B6C3F1, male (NCI) | diet | IRIS |
| Arsenic | A | Inhalation | 1.5E+01 | Lung | lung cancer | human, male | human, male | IRIS |
| | | Oral | 1.5E+00 | Skin | -- | human | drinking water | IRIS |
| Benz[a]anthracene | B2 | Inhalation | 6.1E+00 | -- | -- | -- | -- | Other EPA Docs. |
| | | Oral | 7.3E-01 | -- | -- | -- | -- | NCEA |
| Benzo[a]pyrene | B2 | Inhalation | 6.1E+00 | Respiratory tract | -- | Hamster | Inhalation | HEAST |
| | | Oral | 7.3E+00 | Forestomach | Squamous cell carcinoma | CFW mice, sex unknown | oral, diet | IRIS |
| Benzo[b]fluoranthene | B2 | Inhalation | 6.1E+00 | -- | -- | -- | -- | Other EPA Docs. |
| | | Oral | 7.3E-01 | -- | -- | -- | -- | NCEA |
| Benzo[k]fluoranthene | B2 | Inhalation | 6.1E+00 | -- | -- | -- | -- | Other EPA Docs. |
| | | Oral | 7.3E-02 | -- | -- | -- | -- | NCEA |
| Beryllium | B2 | Inhalation | 8.4E+00 | Lung | Lung tumors | human | human | IRIS |
| | | Oral | 4.3E+00 | Whole body | gross tumors, all sites combined | rat/Long-Evans, male | drinking water | IRIS |
| Cadmium | B1 | Inhalation | 6.3E+00 | Lung, trachea, bronchus | lung, trachea, bronchus cancer deaths | human/white male | human/white male | IRIS |
| | | Oral | NA | -- | -- | -- | -- | -- |

Abbreviations used: NCEA: EPA's National Center for Environmental Assessment; HEAST: EPA's Health Effects Assessment Summary Tables; IRIS: EPA's Integrated Risk Information System database; NA: Not Available; O: Oral

## Table 5-23
## Toxicity Estimates for Noncarcinogenic Effects for the Bainbridge Naval Training Center, Port Deposit, Maryland

| Chemical | Exposure Route | RfD Type | Reference Dose (mg/kg-day) | Uncert Factor | Mod Factor | Confi-dence Level | Target Organ | Critical Effect | Refer-ence Source | Date |
|---|---|---|---|---|---|---|---|---|---|---|
| Aldrin | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | Oral | Chronic | 3.0E-05 | 1000 | 1 | Medium | Liver | Liver toxicity | IRIS | 3/1/88 |
| | | Subchronic | 3.0E-05 | 1000 | -- | -- | Liver | Lesions | HEAST | 5/31/95 |
| Aluminum | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | Oral | Chronic | 1.0E+00 | 100 | -- | Medium | Offspring | Developmental Effects | NCEA | 6/20/94 |
| | | Subchronic | 1.0E+00 | 100 | -- | Medium | Offspring | Developmental Effects | NCEA | |
| Antimony | Inhalation | Chronic | 1.7E-06 | 1000 | -- | Medium | Lung | Alveolar macrophages | NCEA | 11/23/93 |
| | Oral | Chronic | 4.0E-04 | 1000 | 1 | Low | Whole body | Longevity, blood glucose, and cholesterol | IRIS | 2/1/91 |
| | | Subchronic | 4.0E-04 | 1000 | -- | -- | Whole body | Increased mortality | HEAST | 5/31/95 |
| Arsenic | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | Oral | Chronic | 3.0E-04 | 3 | 1 | Medium | Skin | Hyperpigmentation, keratosis and possible vascular complications | IRIS | 3/1/93 |
| | | Subchronic | 3.0E-04 | 3 | -- | -- | Skin | Keratosis, hyperpigmentation | HEAST | 5/31/95 |
| Benz[a]anthracene | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | Oral | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | | Subchronic | NA | -- | -- | -- | -- | -- | -- | |
| Benzo[a]pyrene | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | Oral | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | | Subchronic | NA | -- | -- | -- | -- | -- | -- | |
| Benzo[b]fluoranthene | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |

Abbreviations used: NCEA: National Center for Environmental Assessment; HEAST: EPA's Health Effects Assessment Summary Tables; IRIS: EPA's Integrated Risk Information System database; NA: Not Available

Table 5-23

Toxicity Estimates for Noncarcinogenic Effects for the Bainbridge Naval Training Center, Port Deposit, Maryland

| Chemical | Exposure Route | RfD Type | Reference Dose (mg/kg-day) | Uncert Factor | Mod Factor | Confidence Level | Target Organ | Critical Effect | Reference Source | Date |
|---|---|---|---|---|---|---|---|---|---|---|
| Benzo[b]fluoranthene | Oral | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | | Subchronic | NA | -- | -- | -- | -- | -- | -- | |
| Benzo[k]fluoranthene | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | Oral | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | | Subchronic | NA | -- | -- | -- | -- | -- | -- | |
| Beryllium | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | Oral | Chronic | 5.0E-03 | 100 | 1 | Low | -- | No adverse effects | IRIS | 2/1/93 |
| | | Subchronic | 5.0E-03 | 100 | -- | -- | -- | None observed | HEAST | 5/31/95 |
| Cadmium | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | Oral | Chronic | 5.0E-04 | 10 | 1 | High | Kidney | Significant proteinuria | IRIS | 2/1/94 |
| | | Subchronic | 5.0E-04 | -- | -- | -- | -- | -- | Chr. Oral RfD | |
| Chlordane | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | Oral | Chronic | 6.0E-05 | 1000 | 1 | Low | Liver | Regional liver hypertrophy in females | IRIS | 7/1/89 |
| | | Subchronic | 6.0E-05 | 1000 | -- | -- | Liver | Hypertrophy | HEAST | 5/31/95 |
| Chlorobenzene | Inhalation | Chronic | 5.7E-03 | 10000 | -- | -- | Liver | Effects | HEAST | 5/31/95 |
| | Oral | Chronic | 2.0E-02 | 1000 | 1 | Medium | Liver | Histopathologic changes in liver | IRIS | 7/1/93 |
| | | Subchronic | 2.0E-02 | -- | -- | -- | -- | -- | Chr. Oral RfD | |
| Chloroform | Inhalation | Chronic | 1.1E-02 | 300 | -- | Medium | Liver | Necrosis | NCEA | |
| | Oral | Chronic | 1.0E-02 | 1000 | 1 | Medium | Liver | Fatty cyst formation in liver | IRIS | 9/1/92 |

Abbreviations used: NCEA: National Center for Environmental Assessment; HEAST: EPA's Health Effects Assessment Summary Tables; IRIS: EPA's Integrated Risk Information System database; NA: Not Available

Table 5-22
Toxicity Indices for Carcinogenic Effects of COPCs at the Bainbridge Naval Training Center, Port Deposit, Maryland

| Chemical | Carcinogen Class | Exposure Route | Slope Factor $(mg/kg\text{-}day)^{-1}$ | Target Organ | Tumor Type | Basis Species | Basis Exposure Route | Reference Source |
|---|---|---|---|---|---|---|---|---|
| Chlordane | B2 | Inhalation | 1.3E+00 | Liver | hepatocellular carcinoma | mouse/CD-1 (Velsicol); mouse/B6C3F1 (NCI) | diet | IRIS |
| | | Oral | 1.3E+00 | Liver | hepatocellular carcinoma | mouse/CD-1 (Velsicol); mouse/B6C3F1 (NCI) | diet | IRIS |
| Chloroform | B2 | Inhalation | 8.0E-02 | Liver | hepatocellular carcinoma | mouse, B6C3F1, female | mouse, B6C3F1, female | IRIS |
| | | Oral | 6.1E-03 | Kidney | all kidney tumors | rat/Osborne-Mendel, male | drinking water | IRIS |
| Chromium(VI) | A | Inhalation | 4.2E+01 | Lung | lung cancer | human | human | IRIS |
| | | Oral | NA | -- | -- | -- | -- | -- |
| Chrysene | B2 | Inhalation | 6.1E+00 | -- | -- | -- | -- | Other EPA Docs. |
| | | Oral | 7.3E-03 | -- | -- | -- | -- | NCEA |
| Di(2-ethylhexyl)phthalate | B2 | Inhalation | NA | -- | -- | -- | -- | -- |
| | | Oral | 1.4E-02 | Liver | Mouse/B6C3F1, male | hepatocellular carcinoma and adenoma | diet | IRIS |
| Dibenz[a,h]anthracene | B2 | Inhalation | 6.1E+00 | -- | -- | -- | -- | NCEA |
| | | Oral | 7.3E+00 | -- | -- | -- | -- | NCEA |
| Dichlorobenzene, 1,4- | C | Inhalation | NA | -- | -- | -- | -- | -- |
| | | Oral | 2.4E-02 | Liver | -- | Mouse | Gavage | HEAST |

Abbreviations used: NCEA: EPA's National Center for Environmental Assessment; HEAST: EPA's Health Effects Assessment Summary Tables;
IRIS: EPA's Integrated Risk Information System database; NA: Not Available; O: Oral

Table 5-22

Toxicity Indices for Carcinogenic Effects of COPCs at the Bainbridge Naval Training Center, Port Deposit, Maryland

| Chemical | Carcinogen Class | Exposure Route | Slope Factor (mg/kg-day)$^{-1}$ | Target Organ | Tumor Type | Basis Species | Basis Exposure Route | Reference Source |
|---|---|---|---|---|---|---|---|---|
| Dichloropropane, 1,2- | B2 | Inhalation | NA | -- | -- | -- | -- | -- |
| | | Oral | 6.8E-02 | Liver | -- | Mouse | Gavage | HEAST |
| Heptachlor | B2 | Inhalation | 4.5E+00 | Liver | hepatocellular carcinomas | mouse/C3H; mouse/B6C3F1 | diet | IRIS |
| | | Oral | 4.5E+00 | Liver | hepatocellular carcinomas | mouse/C3H; mouse/B6C3F1 | diet | IRIS |
| Indeno[1,2,3-cd]pyrene | B2 | Inhalation | 6.1E+00 | -- | -- | -- | -- | Other EPA Docs. |
| | | Oral | 7.3E-01 | -- | -- | -- | -- | NCEA |
| Methylene chloride | B2 | Inhalation | 1.6E-03 | Liver, lung | combined adenomas and carcinomas | mouse/B6C3F1, female | mouse/B6C3F1, female | IRIS |
| | | Oral | 7.5E-03 | Liver | Hepatocellular adenomas or carcinomas (NTP) and hepatocellular cancer and neoplastic nodules (NCA) | Mouse/B6C3F1 (female, NTP; male, NCA) | Inhalation (NTP); drinking water (NCA) | IRIS |
| Tetrachloroethane, 1,1,2,2- | C | Inhalation | 2.0E-01 | Liver | Hepatocellular carcinoma | Mouse/B6CC3F1 | Gavage | IRIS |
| | | Oral | 2.0E-01 | Liver | Hepatocellular carcinoma | Mouse/B6CC3F1 | Gavage | IRIS |
| Trichloroethylene | B2 | Inhalation | 6.0E-03 | Liver | -- | Mouse | Inhalation | NCEA |
| | | Oral | 1.1E-02 | Liver | -- | Mouse | Gavage | NCEA |
| Vinyl Chloride | A | Inhalation | 3.0E-01 | Liver | -- | Rat | Inhalation | HEAST |
| | | Oral | 1.9E+00 | Lung, Liver | -- | Rat | diet | HEAST |

Abbreviations used: NCEA: EPA's National Center for Environmental Assessment; HEAST: EPA's Health Effects Assessment Summary Tables; IRIS: EPA's Integrated Risk Information System database; NA: Not Available; O: Oral

Table 5-23

Toxicity Estimates for Noncarcinogenic Effects for the Bainbridge Naval Training Center, Port Deposit, Maryland

| Chemical | Exposure Route | RfD Type | Reference Dose (mg/kg-day) | Uncert Factor | Mod Factor | Confi-dence Level | Target Organ | Critical Effect | Refer-ence Source | Date |
|---|---|---|---|---|---|---|---|---|---|---|
| Chloroform | Oral | Subchronic | 1.0E-02 | 1000 | -- | -- | Liver | Lesions | HEAST | 5/31/95 |
| Chromium(VI) | Inhalation | Chronic | 1.1E-06 | 100 | -- | Low | Respiratory tract | Diffuse nasal symptoms | NCEA | 5/14/93 |
| | Oral | Chronic | 5.0E-03 | 500 | 1 | Low | -- | No effects reported | IRIS | 2/1/95 |
| | | Subchronic | 2.0E-02 | 100 | -- | -- | -- | None observed | HEAST | 5/31/95 |
| Chrysene | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | Oral | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | | Subchronic | NA | -- | -- | -- | -- | -- | -- | |
| Di(2-ethylhexyl)phthalate | Inhalation | Chronic | 2.9E-03 | 1000 | -- | Low | Lung | Effects | NCEA | 3/18/96 |
| | Oral | Chronic | 2.0E-02 | 1000 | 1 | Medium | Liver | Increased relative liver weight | IRIS | 5/1/91 |
| | | Subchronic | 2.0E-02 | 3000 | -- | Medium | Testes | Decreased weight, changes in enzyme levels | NCEA | 3/28/96 |
| Dibenz[a,h]anthracene | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | Oral | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | | Subchronic | NA | -- | -- | -- | -- | -- | -- | |
| Dichlorobenzene, 1,4- | Inhalation | Chronic | 2.3E-01 | 100 | 1 | Medium | Liver | Increased liver weights in P1 males | IRIS | 1/1/94 |
| | Oral | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | | Subchronic | NA | -- | -- | -- | -- | -- | -- | |
| Dichloroethylene, 1,2- (Mixed isomers) | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | Oral | Chronic | 9.0E-03 | 1000 | -- | -- | Liver | Lesions | HEAST | 3/31/93 |
| | | Subchronic | 9.0E-03 | 1000 | -- | -- | Liver | Lesions | HEAST | 3/31/93 |

Abbreviations used: NCEA: National Center for Envionmental Assessment; HEAST: EPA's Health Effects Assessment Summary Tables; IRIS: EPA's Integrated Risk Information System database; NA: Not Available

Table 5-23

Toxicity Estimates for Noncarcinogenic Effects for the Bainbridge Naval Training Center, Port Deposit, Maryland

| Chemical | Exposure Route | RfD Type | Reference Dose (mg/kg-day) | Uncert Factor | Mod Factor | Confidence Level | Target Organ | Critical Effect | Reference Source | Date |
|---|---|---|---|---|---|---|---|---|---|---|
| Dichloropropane, 1,2- | Inhalation | Chronic | 1.1E-03 | 300 | 1 | Medium | Nose | Hyperplasia of the nasal mucosa | IRIS | 12/1/91 |
| | Oral | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | | Subchronic | NA | -- | -- | -- | -- | -- | -- | |
| Heptachlor | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | Oral | Chronic | 5.0E-04 | 300 | 1 | Low | Liver | Liver weight increases in males only | IRIS | 3/1/91 |
| | | Subchronic | 5.0E-04 | 300 | -- | -- | Liver | Increased weight | HEAST | 3/31/93 |
| Indeno[1,2,3-cd]pyrene | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | Oral | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | | Subchronic | NA | -- | -- | -- | -- | -- | -- | |
| Iron | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | Oral | Chronic | 3.0E-01 | -- | -- | -- | -- | Iron Overload | NCEA | |
| | | Subchronic | 3.0E-01 | -- | -- | -- | -- | Iron Overload | NCEA | |
| Manganese | Inhalation | Chronic | 1.4E-05 | 1000 | 1 | Medium | -- | Impairment of neurobehavioral function | IRIS | 12/1/93 |
| | Oral | Chronic | 2.0E-02 | 3 | 1 | Medium | -- | CNS effects | IRIS | 11/1/95 |
| | | Subchronic | 2.0E-02 | -- | -- | -- | -- | -- | Chr. Oral RfD | |
| Methylene chloride | Inhalation | Chronic | 8.6E-01 | 100 | -- | -- | Liver | Liver toxicity | HEAST | |
| | Oral | Chronic | 6.0E-02 | 100 | 1 | Medium | Liver | Liver toxicity | IRIS | 3/1/88 |
| | | Subchronic | 6.0E-02 | 100 | -- | -- | Liver | Liver toxicity | HEAST | |
| Nickel, soluble salts | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |

Abbreviations used: NCEA: National Center for Environmental Assessment; HEAST: EPA's Health Effects Assessment Summary Tables; IRIS: EPA's Integrated Risk Information System database; NA: Not Available

Table 5-23

Toxicity Estimates for Noncarcinogenic Effects for the Bainbridge Naval Training Center, Port Deposit, Maryland

| Chemical | Exposure Route | RfD Type | Reference Dose (mg/kg-day) | Uncert Factor | Mod Factor | Confi-dence Level | Target Organ | Critical Effect | Refer-ence Source | Date |
|---|---|---|---|---|---|---|---|---|---|---|
| Nickel, soluble salts | Oral | Chronic | 2.0E-02 | 300 | 1 | Medium | Whole body | Decreased body and organ weights | IRIS | 1/1/92 |
| | | Subchronic | 2.0E-02 | 300 | -- | -- | Whole body | Decreased weight | HEAST | 5/31/95 |
| Tetrachloroethane, 1,1,2,2- | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | Oral | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | | Subchronic | NA | -- | -- | -- | -- | -- | -- | |
| Thallium | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | Oral | Chronic | 7.0E-05 | 3000 | -- | -- | Liver | Increased levels of SGOT and LDH | IRIS | 9/1/90 |
| | | Subchronic | 7.0E-04 | 300 | -- | -- | Liver | Increased SGOT, and LDH; Alopecia | HEAST | 5/31/95 |
| Trichloroethylene | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | Oral | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | | Subchronic | NA | -- | -- | -- | -- | -- | -- | |
| Vanadium | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | Oral | Chronic | 7.0E-03 | 100 | -- | -- | -- | -- | HEAST | |
| | | Subchronic | 7.0E-03 | 100 | -- | -- | -- | -- | HEAST | |
| Vinyl chloride | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | Oral | Chronic | NA | -- | -- | -- | -- | -- | -- | |
| | | Subchronic | NA | -- | -- | -- | -- | -- | -- | |
| Zinc and Compounds | Inhalation | Chronic | NA | -- | -- | -- | -- | -- | -- | |

Abbreviations used: NCEA: National Center for Environmental Assessment; HEAST: EPA's Health Effects Assessment Summary Tables; IRIS: EPA's Integrated Risk Information System database; NA: Not Available

Table 5-23
Toxicity Estimates for Noncarcinogenic Effects for the Bainbridge Naval Training Center, Port Deposit, Maryland

| Chemical | Exposure Route | RfD Type | Reference Dose (mg/kg-day) | Uncert Factor | Mod Factor | Confidence Level | Target Organ | Critical Effect | Reference Source | Date |
|---|---|---|---|---|---|---|---|---|---|---|
| Zinc and Compounds | Oral | Chronic | 3.0E-01 | 3 | 1 | Medium | Blood | 47% Decrease in erythrocyte superoxide dismutase (ESOD) concentration in adult females after 10 week | IRIS | 10/1/92 |
| | | Subchronic | 3.0E-01 | 3 | -- | -- | Blood | Decreased blood enzyme | HEAST | 5/31/95 |

Abbreviations used: NCEA: National Center for Environmental Assessment; HEAST: EPA's Health Effects Assessment Summary Tables; IRIS: EPA's Integrated Risk Information System database; NA: Not Available

## Table 5-24

## DERMAL TOXICITY VALUES

| COPC | Oral Absorption Fraction | Reference | Dermal RfD | Dermal SF |
|---|---|---|---|---|
| Aluminum | 0.05 | C | 5E-02 | — |
| Antimony | 0.1 | B | 4.0E-5 | — |
| Arsenic | 0.95 | E | 2.8E-4 | 1.6 |
| Beryllium | 0.01 | B | 5.0E-5 | 430 |
| Cadmium | 0.05 | D | 2.5E-5 | — |
| Chromium VI | 0.1 | B | 5E-04 | — |
| Iron | 0.1 | A | 3E-02 | — |
| Manganese | 0.1 | F | 2E-03 | — |
| Nickel | 0.05 | G | 1E-03 | — |
| Thallium | 0.95 | B | 6.6E-5 | — |
| Vanadium | 0.01 | B | 7.0E-5 | — |
| Zinc | 0.25 | E | 7.5E-2 | — |
| Aldrin | 1.0 | B | 3E-05 | 1.7 |
| Clordane | 0.8 | B | 4.8E-5 | 1.6 |
| Heptachlor | 1.0 | B | 5E-04 | 4.5 |
| 1,4-Dichlorobenzene | 1.0 | B | 2.3E-01 | 2.4E-02 |
| Di(2-ethylhexyl)phthalate | 0.5 | B | 1E-02 | 2.8E-02 |
| 1,1,2,2-Tetrachloroethane | 1.0 | B | — | 2E-01 |
| 1,2-Dichloroethene | 1.0 | E | 9E-03 | — |
| Chlorobenzene | 0.5 | B | 1E-02 | — |
| Chloroform | 1.0 | B, E | 1E-02 | 6.1E-03 |
| Methylene chloride | 1.0 | B | 6E-02 | 7.5E-03 |
| Trichloroethene | 1.0 | B | — | 1.1E-02 |
| Vinyl chloride | 1.0 | B, E | — | 1.9 |

Key:

A = Estimate from data in Recommended Dietary Allowances (NRC 1989).
B = Estimate from data in ATSDR Toxicological Profile.
C = Assumed. Aluminum is poorly absorbed through the GI tract (ATSDR 1992).
D = IRIS (EPA 1995b).
E = ECAO (EPA 1993h). Recommended oral absorption values.
F = IRIS. Upper end of range of absorption reported for dietary manganese.
G = ECAO (EPA 1993h). Middle of range reported for oral absorption of soluble nickel salts.
COPC = Chemical Potential Concern.
RfD = Reference dose.
SF = Slope factor.
— = None available.

Table 5-25

SUMMARY OF CANCER RISKS ASSOCIATED WITH THE BAINBRIDGE NTC - REASONABLE MAXIMUM EXPOSURES

| Scenario | Receptor | Estimated Cancer Risk | Risk Contribution by Route | Risk Contribution by Chemical |
|---|---|---|---|---|
| **Site 1: Old Landfill** | | | | |
| Recreational Exposure to Sediment | Adolescent | 3.1E-06 | Dermal absorption - 86%<br>Sediment ingestion - 14% | Beryllium - 87%<br>Carcinogenic PAHs - 9%<br>Arsenic - 4% |
| Residential groundwater use | Adult | 7.8E-05 | Water ingestion - 69%<br>Vapor inhalation - 16%<br>Dermal absorption - 15% | Vinyl chloride - 26%<br>Arsenic - 23%<br>Beryllium - 21%<br>Chloroform - 8%<br>Di(2-ethylhexyl)phthalate - 7%<br>1,4-Dichlorobenzene - 6%<br>Heptachlor - 4%<br>Trichloroethere - 2% |
| | Child | 2.9E-05 | Water ingestion - 88%<br>Dermal absorption - 12% | Arsenic - 30%<br>Vinyl Cloride - 25%<br>Beryllium - 25%<br>Di(2-ethylhexyl)phthalate - 7%<br>1,4-Dichlorobenzene - 7%<br>Heptochlor - 3%<br>Trichloroethere - 1% |
| **Site 2: Fire Training Area** | | | | |
| Recreational Exposure to Sediment | Adolescent | 1.3E-06 | Dermal absorption - 95%<br>Sediment ingestion - 5% | Beryllium - 97%<br>Arsenic - 3% |
| Residential Exposure to Soil | Adult/child | 3.3E-06 | Soil ingestion - 59%<br>Dermal absorption - 41% | Arsenic - 100% |
| | Child | 1.8E-6 | Soil ingestion - 75%<br>Dermal absorption - 25% | Arsenic - 100% |

## Table 5-25

## SUMMARY OF CANCER RISKS ASSOCIATED WITH THE BAINBRIDGE NTC - REASONABLE MAXIMUM EXPOSURES

| Scenario | Receptor | Estimated Cancer Risk | Risk Contribution by Route | Risk Contribution by Chemical |
|---|---|---|---|---|
| Residential Groundwater Use | Adult | 5.4E-04 | Water ingestion - 78%<br>Vapor inhalation - 13%<br>Dermal absorption - 9% | Carcinogenic PAHs - 50%<br>Beryllium - 36%<br>1,1,2,2-Tetrachloroethane - 5%<br>Arsenic - 4%<br>Aldrin - 2%<br>Chloroform - 2% |
| | Child | 2.0E-04 | Wateringestion - 99%<br>Dermal absorption - 1% | Carcinogenic PAHs - 52%<br>Beryllium - 37%<br>Arsenic - 5%<br>1,1,2,2-Tetrachloroethane - 3%<br>Aldrin - 1%<br>Chloroform - 1% |

Key:

PAHs = Polynuclear aromatic hydrocarbons.

Note: This table presents upper-bound estimates of risk which were derived using conservative assumptions. See discussions of these risk estimates in Sections 5.5.2.1 and 5.5.2.2.

Table 5-26

SUMMARY OF NON-CANCER RISKS ASSOCIATED WITH THE BAINBRIDGE NTC - REASONABLE MAXIMUM EXPOSURES

| Scenario | Receptor | Estimated Non Cancer Risk | Risk Contribution by Route | Hazard Index by Chemical |
|---|---|---|---|---|
| **Site 1: Old Landfill** | | | | |
| Recreational Exposure to Sediment | Adolescent | 0.14 | Dermal absorption - 78%<br>Sediment ingestion - 22% | -- |
| Residential groundwater use | Adult | 16 | Water ingestion - 92%<br>Vapor inhalation - 5%<br>Dermal absorption - 3% | Manganese - 9.8<br>Iron - 2.3<br>Antimony - 2.1<br>Chlorobenzene - 0.9<br>Thallium - 0.4 |
| | Child | 35 | Water ingestion - 98%<br>Dermal absorption - 2% | Manganese - 23<br>Iron - 5.3<br>Antimony - 4.9<br>Thallium - 0.9<br>Chlorobenzene - 0.4 |
| **Site 2: Fire Training Area** | | | | |
| Recreational Exposure to Sediment | Adolescent | 0.035 | Dermal absorption - 76%<br>Sediment ingestion - 24% | -- |
| Residential Exposure to Soil | Adult/child | 1.3 | Dermal absorption - 71%<br>Soil ingestion - 29% | -- |
| | Child | 2.8 | Dermal absorption - 53%<br>Soil ingestion - 47% | Iron - 1.5 |
| Residential Groundwater Use | Adult | 16 | Water ingestion - 97%<br>Dermal absorption - 3% | Manganese - 7.7<br>Iron - 7.4 |
| | Child | 37 | Water ingestion - 98%<br>Dermal absorption - 2% | Manganese - 18<br>Iron - 17 |

Note: This table presents upper-bound estimates of risk which were derived using conservative assumptions. See discussions of these risk estimates in Sections 5.5.2.1 and 5.5.2.2.

Table 5-27

COMPARISON OF REASONABLE MAXIMUM EXPOSURE AND CENTRAL TENDENCY EXPOSURE CASES RESIDENTIAL GROUNDWATER USE ADULT RECEPTOR

| | ExposureCases | | |
|---|---|---|---|
| | RME | CT | CT/RME |
| **Drinking Water Ingestion** | | | |
| Ingestion rate (L/day) | 2 | 1.4[a] | 0.7 |
| **Dermal Absorption While Showering** | | | |
| Skin area ($cm^2$) | 20,000 | 20,000[b] | 1.0 |
| Exposure time (hr) | 0.25 | 0.167[b] | 0.667 |
| **Vapor Inhalation from Showering** | | | |
| Inhalation rate (4 min) | 14 | 10[c] | 0.71 |
| Exposure time (minutes) | 20 | 13[d] | 0.65 |
| **All Routes** | | | |
| Exposure frequency (day/year) | 350 | 350[a] | 1.0 |
| Exposure duration (years) | 30 | 9[a] | 0.3 |
| **Site 1: Old Landfill** | | | |
| Estimated cancer risk | $7.8E^{-5}$ | $1.5E^{-5}$ | 0.2 |
| Estimated HI manganese | 9.8 | 6.8 | 0.7 |
| Estimated HI iron | 2.3 | 1.6 | 0.7 |
| Estimated HI antimony | 2.1 | 1.5 | 0.7 |
| Estimated HI thallium | 0.4 | 0.3 | 0.7 |
| Estimated HI chlorobenzene | 0.9 | 0.3 | 0.3 |
| **Site 2: Fire Training Area** | | | |
| Estimated cancer risk | $5.4E^{-4}$ | $1.0E^{-4}$ | 0.2 |
| Estimated HI iron | 7.4 | 5.2 | 0.7 |
| Estimated HI manganese | 7.7 | 5.4 | 0.7 |

[a] Obtained from EPA 1993f.
[b] Obtained from EPA 1992c.
[c] Inhalation rate for light activity, obtained from EPA 1989b.
[d] Shower time of 10 minutes plus 3 minutes drying time.

Key:

RME = Reasonable Maximum Exposure.
CT = Central Tendency.

# C

# Tables from the Desktop Ecological Risk Assessment of the Remedial Investigation Report

## C. Tables from the Desktop Ecological Risk Assessment of the Remedial Investigation Report.

Appendix C contains tables from the Desktop Ecological Risk Assessment of the Remedial Investigation Report (Appendix Q), prepared by the United States Fish and Wildlife Service (October 1998). These provide supporting material for the Ecological Risk Management Recommendations included as Appendix E of this report.

Table 3. Comparison of maximum concentrations with EPA Region III BTAG screening levels : Old Landfill.

| | Sediment (ug/kg organics; mg/kg metals) | | | | | | Water (ug/L) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Contaminant | Maximum Sediment Concentration | Number of Detections | Total Number of Samples | Benchmark | Reference Source | Hazard Quotient | Maximum Water Concentration | Number of Detections | Total Number of Samples | Benchmark | Reference Source | Hazard Quotient |
| **Low Molecular Weight PAHs** | | | | | | | | | | | | |
| 2-methylnaphalene | 500 | 3 | 28 | 70 | x - fauna | 7.1 | ND | | 29 | NB | NB | |
| Acenaphthene | 180 | 6 | 28 | 16 | x - fauna | 11 | ND | | 29 | 520 | x - fauna | |
| Acenaphthylene | 15000 | 3 | 28 | 44 | x - fauna | 341 | ND | | 29 | NB | NB | |
| Anthracene | 27000 | 13 | 28 | 85.3 | x - fauna | 317 | ND | | 29 | 0.1 | x - fauna | |
| Fluorene | 13000 | 8 | 28 | 19 | x - fauna | 684 | ND | | 29 | 430 | x - fauna | |
| Naphthalene | 1700 | 4 | 28 | 160 | x - fauna | .11 | ND | | 29 | 100 | x - fauna | |
| Phenanthrene | 120000 | 24 | 28 | 240 | x - fauna | 500 | ND | | 29 | 6.3 | x - fauna | |
| Total Low Molecular Weight PAHs | NA | | | 552 | a | | NA | | | NB | NB | |
| **High Molecular Weight PAHs** | | | | | | | | | | | | |
| Benzo(a)anthracene | 47000 | 22 | 28 | 261 | x - fauna | 180 | NA | | | 6.3 | x - fauna | |
| Benzo(a)pyrene | 54000 | 22 | 28 | 430 | x - fauna | 126 | NA | | | 0.014 | e | |
| Benzo(b)fluoranthene | 74000 | 26 | 28 | 3200 | x - fauna | 23 | NA | | | NB | NB | |
| Benzo(g,h,i)perylene | 36000 | 18 | 28 | 670 | x - fauna | 54 | NA | | | NB | NB | |
| Benzo(k)fluoranthene | 35000 | 20 | 28 | NB | | | NA | | | NB | NB | |
| Chrysene | 55000 | 23 | 28 | 384 | x - fauna | 143 | ND | | 29 | NB | NB | |
| Dibenz(a,h)anthracene | 9100 | 9 | 28 | 63.4 | x - fauna | 144 | NA | | | NB | NB | |
| Fluoranthene | 120000 | 27 | 28 | 600 | x - fauna | 200 | ND | | 29 | 3980 | x - fauna | |
| Indeno(1,2,3-c,d)pyrene | 38000 | 21 | 28 | 600 | x - fauna | 63 | NA | | | NB | NB | |
| Pyrene | 89000 | 27 | 28 | 665 | x - fauna | 134 | ND | | 29 | NB | NB | |
| Total High Molecular Weight PAHs | | | | 1700 | a | | NA | | | NB | NB | |
| Total PAHs | | | | 4022 | a | | NA | | | NB | NB | |
| **Other Semi-Volatile Compounds** | | | | | | | | | | | | |
| 1,4-Dichlorobenzene | 100 | 2 | 28 | 110 | x - fauna | 0.9 | 9 | 4 | 29 | 763 | d | 0.01 |
| bis(2-ethylhexyl)phthalate | NA | | | 1300 | x - fauna | | 22 | 1 | 29 | 30 | x - fauna | 0.7 |
| Butylbenzylphthalate | NA | | | 63 | x - fauna | | NA | | | 3.0 | x - fauna | |
| Carbozole | 110 | 3 | 12 | NB | NB | | NA | | | NB | NB | |
| Dibenzofuran | 6600 | 3 | 28 | 540 | x - fauna | 12 | ND | | | 20.4 | e | |
| Diethylphthalate | 1300 | 4 | 28 | 200 | x - fauna | 6.5 | 430 | 1 | 29 | 3 | e | 143 |
| Di-n-butylphthalate | 320 | 2 | 28 | 1400 | x - fauna | 0.2 | NA | | | 0.3 | x - fauna | |
| **Volatile Organic Compounds** | | | | | | | | | | | | |
| Acetone | ND | | 28 | NB | NB | | 27 | 4 | 29 | 11200 | e | 0.002 |
| Carbon Disulfide | 4 | 1 | 28 | NB | NB | | 290 | 5 | 29 | 2.0 | x - fauna | 145 |
| Chlorobenzene | NA | | | NB | NB | | 15 | 4 | 29 | 50 | x - fauna | 0.3 |
| Chloroform | 5 | 1 | 28 | NB | NB | | 9 | 4 | 29 | 1240 | x - fauna | 0.01 |
| Ethylbenzene | ND | | 28 | 10 | x - fauna | | 1 | 1 | 29 | 32000 | x - fauna | 0.000 |
| Tetrachloroethene | 3 | 1 | 28 | NB | NB | | ND | | 29 | 125 | e | |
| Toluene | ND | 2 | 28 | NB | NB | | 1 | 1 | 29 | 17000 | x - fauna | 0.0001 |
| Trichloroethene | 9 | 2 | 28 | NB | NB | | 8 | 6 | 29 | NB | NB | |
| Xylenes (Total) | ND | 2 | 28 | 40 | x - fauna | | 2 | 4 | 29 | 6000 | x - fauna | 0.0003 |
| **Pesticides/PCB** | | | | | | | | | | | | |
| 4,4'-DDD | 220 | 22 | 28 | 16 | x - fauna | 14 | 0.81 | 1 | 29 | 0.6 | x - fauna | 1.4 |
| 4,4'-DDE | 200 | 24 | 28 | 2.2 | x - fauna | 91 | 0.18 | 1 | 29 | 1050 | x - fauna | 0.0002 |
| 4,4'-DDT | 440 | 23 | 28 | 1.58 | x - fauna | 278 | 0.11 | 1 | 29 | 0.001 | x - fauna | 110 |
| Aldrin | 2.5 | 1 | 28 | 2 | a | 1.3 | NA | | | 3.0 | x - fauna | |
| alpha-Chlordane | 280 | 9 | 28 | 0.5 | b | 560 | NA | | | 0.0043 | x - fauna | |
| gamma-Chlordane | 410 | 7 | 28 | 0.5 | b | 820 | NA | | | 0.0043 | x - fauna | |
| Heptachlor | 29 | 2 | 28 | NB | NB | | NA | | | 0.0038 | x - fauna | |
| Methoxychlor | NA | | | NB | NB | | 0.31 | 1 | 29 | 0.03 | x - fauna | 10.3 |
| **Metals** | | | | | | | | | | | | |

Table 3. Comparison of maximum concentrations with EPA Region III BTAG screening levels : Old Landfill.

| Contaminant | Sediment (ug/kg organics; mg/kg metals) Maximum Sediment Concentration | Number of Detections | Total Number of Samples | Benchmark | Reference Source | Hazard Quotient | Water (ug/L) Maximum Water Concentration | Number of Detections | Total Number of Samples | Benchmark | Reference Source | Hazard Quotient |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aluminum | 9680 | 28 | 28 | NB | NB | | 399000 | 27 | 29 | 25 | x - fauna | 15960 |
| Antimony | 17.9 | 1 | 28 | 150 | x - fauna | 0.1 | 58.7 | 1 | 29 | 30 | x - fauna | 2.0 |
| Arsenic (total) | 2.1 | 23 | 28 | 8.2 | x - fauna | 0.3 | 44.7 | 7 | 29 | 874 | x - fauna | 0.1 |
| Barium | 515 | 28 | 28 | NB | NB | | 2540 | 29 | 29 | 10000 | x - fauna | 0.3 |
| Beryllium | 3.3 | 19 | 28 | NB | NB | | 40.5 | 9 | 29 | 5.3 | x - fauna | 7.6 |
| Cadmium | 3.1 | 5 | 28 | 1.2 | x - fauna | 2.6 | 25.4 | 2 | 29 | 0.53 | x - fauna | 48 |
| Calcium | 30000 | 28 | 28 | NB | NB | . | 83500 | 29 | 29 | 116000 | e' | 0.7 |
| Chromium (total) | 49.4 | 28 | 28 | 5.0 | x - flora | 9.9 | 532 | 10 | 29 | 120 | x - fauna | 4.4 |
| Cobalt | 89.6 | 27 | 28 | NB | NB | | 749 | 14 | 29 | 35000 | x - fauna | 0.02 |
| Copper | 52.3 | 28 | 28 | 34 | x - fauna | 1.5 | 950 | 12 | 29 | 6.5 | x - fauna | 146 |
| Cyanide | 4.1 | 1 | 28 | NB | NB | | NA | | | 5.2 | x - fauna | |
| Iron | 208000 | 28 | 28 | NB | NB | | 833000 | 29 | 29 | 320 | x - fauna | 2603 |
| Lead | 387 | 28 | 28 | 46.7 | x - fauna | 8.3 | 1360 | 23 | 29 | 3.2 | x - fauna | 425 |
| Magnesium | 6650 | 28 | 28 | NB | NB | | 121000 | 29 | 29 | 82000 | e' | 1.5 |
| Manganese | 5600 | 28 | 28 | 460 | c | 12 | 15600 | 29 | 29 | 14500 | x - fauna | 1.1 |
| Mercury | 0.19 | 4 | 28 | 0.15 | x - fauna | 1.3 | 0.81 | 5 | 29 | 0.012 | x - fauna | 68 |
| Nickel | 57.1 | 28 | 28 | 20.9 | x - fauna | 2.7 | 614 | 10 | 29 | 160 | x - fauna | 3.8 |
| Potassium | 2570 | 19 | 28 | NB | NB | | 60300 | 27 | 29 | 53000 | e' | 1.1 |
| Selenium | ND | | 28 | NB | NB | | 22.4 | 2 | 29 | 5.0 | x - fauna | 4.5 |
| Silver | NA | | | 1.0 | x - fauna | | 3.4 | 1 | 29 | 0.0001 | x - fauna | 34000 |
| Sodium | 2820 | 10 | 28 | NB | NB | | 28100 | 29 | 29 | 680000 | e' | 0.04 |
| Vanadium | 68 | 28 | 28 | NB | NB | | 1130 | 15 | 29 | 10000 | x - fauna | 0.1 |
| Zinc | 186 | 28 | 28 | 150 | x - fauna | 2.0 | 2980 | 25 | 29 | 110 | x- fauna | 27 |

NB = No benchmark
NA = Not analyzed
ND = Not detected
a = Long et al. 1995 (ER-L)
b = Long and Morgan 1990 (ER-L)
c = Persuad et al. 1992 (LEL)
d = USEPA AWQC 1992 (Chronic Criteria)
e = Suter and Mabrey 1994 (SCV)
e' = Suter and Mabrey 1994 (LCV)

x - fauna = Region III BTAG Screening Level for fauna (lowest of flora and fauna chosen)
x - flora = Region III BTAG Screening Level for flora (lowest of flora and fauna chosen)
ug/L = micrograms per liter (ppb)
ug/kg=micrograms per kilogram (ppb)
mg/L = milligrams per liter (ppm)
HQ = Hazard Quotient = maximum concentration divided by benchmark

Table 4. Comparison of maximum concentrations with EPA Region III BTAG screening levels: Fire Training Area.

| | Sediment (ug/kg organics, mg/kg metals) | | | | | | Water (ug/L) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Contaminant | Maximum Sediment Concentration | Number of Detections | Total Number of Samples | Benchmark | Reference Source | Hazard Quotient | Maximum Water Concentration | Number of Detections | Total Number of Samples | Benchmark | Reference Source | Hazard Quotient | Soil Maximum Concentration |
| **Low Molecular Weight PAHs** | | | | | | | | | | | | | |
| Anthracene | 56 | 1 | 10 | 85.3 | x - fauna | 0.7 | NA | | | 0.1 | x - fauna | | NA |
| Phenanthrene | 260 | 2 | 10 | 240 | x - fauna | 1.1 | NA | | | 6.3 | x - fauna | | NA |
| Total Low Molecular Weight PAHs | | | | 552 | a | | NA | | | NB | NB | | NA |
| **High Molecular Weight PAHs** | | | | | | | | | | | | | |
| Benzo(a)anthracene | 150 | 1 | 10 | 261 | x - fauna | 0.6 | NA | | | 6.3 | x - fauna | | NA |
| Benzo(a)pyrene | 70 | 2 | 10 | 430 | x - fauna | 0.2 | NA | | | 0.014 | e | | NA |
| Benzo(b)fluoranthene | 140 | 2 | 10 | 3200 | x - fauna | 0.04 | NA | | | NB | NB | | NA |
| Benzo(g,h,i)perylene | 37 | 1 | 10 | 670 | x - fauna | 0.1 | NA | | | NB | NB | | NA |
| Benzo(k)fluoranthene | 40 | 1 | 10 | NB | | | NA | | | NB | NB | | NA |
| Chrysene | 130 | 2 | 10 | 384 | x - fauna | 0.3 | NA | | | NB | NB | | NA |
| Fluoranthene | 340 | 3 | 10 | 600 | x - fauna | 0.6 | NA | | | 3980 | x - fauna | | NA |
| Indeno(1,2,3-c,d)pyrene | 72 | 1 | 10 | 600 | x - fauna | 0.1 | NA | | | NB | NB | | NA |
| Pyrene | 240 | 3 | 10 | 665 | x - fauna | 0.4 | NA | | | NB | NB | | NA |
| Total High Molecular Weight PAHs | | | | 1700 | a | | NA | | | NB | NB | | NA |
| Total PAHs | | | | 4022 | a | | NA | | | NB | NB | | NA |
| **Other Semi-Volatile Compounds** | | | | | | | | | | | | | |
| bis(2-ethylhexyl)phthalate | 110 | 4 | 10 | 1300 | x - fauna | 0.1 | 12 | 7 | 12 | 30 | x - fauna | 0.4 | NA |
| Butylbenzylphthalate | 110 | 1 | 10 | 63 | x - fauna | 1.7 | NA | | | 3.0 | x - fauna | | NA |
| Diethylphthalate | 22 | 1 | 10 | 200 | x - fauna | 0.1 | NA | | | 3 | e | | NA |
| Di-n-butylphthalate | 40 | 2 | 10 | 1400 | x - fauna | 0.03 | NA | | | 0.3 | x - fauna | | NA |
| **Volatile Organic Compounds** | | | | | | | | | | | | | |
| Acetone | NA | | | NB | NB | | 6 | 1 | 12 | 11200 | e | 0.001 | NA |
| Carbon Disulfide | NA | | | NB | NB | | 2 | 1 | 12 | 2.0 | x - fauna | 1.0 | NA |
| Toluene | 0.5 | 1 | 10 | NB | NB | | NA | | | 17000 | x - fauna | | NA |
| **Pesticides/PCB** | | | | | | | | | | | | | |
| 4,4'-DDD | 9.7 | 7 | 10 | 16 | x - fauna | 0.6 | 14 | 4 | 12 | 0.6 | x - fauna | 23 | 3.9 |
| 4,4'-DDE | 13 | 7 | 10 | 2.2 | x - fauna | 5.9 | 4 | 1 | 12 | 1050 | x - fauna | 0.004 | 38 |
| 4,4'-DDT | 49 | 10 | 10 | 1.58 | x - fauna | 31 | 16 | 1 | 12 | 0.001 | x - fauna | 16000 | 42 |
| **Metals** | | | | | | | | | | | | | |
| Aluminum | 3710 | 7 | 7 | NB | NB | | 33200 | 12 | 12 | 25 | x - fauna | 1328 | NA |
| Antimony | NA | | | 150 | x - fauna | | NA | | | 30 | x - fauna | | NA |
| Arsenic (total) | 1 | 7 | 7 | 8.2 | x - fauna | 0.1 | 58.3 | 4 | 12 | 874 | x - fauna | 0.1 | NA |
| Barium | 50.2 | 7 | 7 | NB | NB | | 867 | 12 | 12 | 10000 | x - fauna | 0.1 | NA |
| Beryllium | 0.38 | 3 | 7 | NB | NB | | 1.6 | 3 | 12 | 5.3 | x - fauna | 0.3 | NA |
| Cadmium | 1.3 | 1 | 7 | 1.2 | x - fauna | 1.1 | 234 | 2 | 12 | 0.53 | x - fauna | 442 | NA |
| Calcium | 863 | 7 | 7 | NB | NB | | 190000 | 12 | 12 | 116000 | e* | 1.6 | NA |
| Chromium (total) | 9.1 | 7 | 7 | 5.0 | x - flora | 1.8 | 80.9 | 4 | 12 | 120 | x - fauna | 0.7 | NA |
| Cobalt | 11 | 6 | 7 | NB | NB | | 127 | 4 | 12 | 35000 | x - fauna | 0.004 | NA |
| Copper | 8.8 | 7 | 7 | 34 | x - fauna | 0.3 | 435 | 4 | 12 | 6.5 | x - fauna | 67 | NA |
| Cyanide | ND | | 7 | NB | NB | | NA | | | 5.2 | x - fauna | | NA |
| Iron | 27800 | 7 | 7 | NB | NB | | 1460000 | 12 | 12 | 320 | x - fauna | 4563 | NA |
| Lead | 35.5 | 7 | 7 | 46.7 | x - fauna | 0.8 | 498 | 10 | 12 | 3.2 | x - fauna | 156 | NA |
| Magnesium | 1320 | 7 | 7 | NB | NB | | 67000 | 12 | 12 | 82000 | e* | 0.8 | NA |
| Manganese | 719 | 7 | 7 | 460 | c | 1.6 | 7080 | 12 | 12 | 14500 | x - fauna | 0.5 | NA |
| Mercury | ND | | 7 | 0.15 | x - fauna | | 0.55 | 2 | 12 | 0.012 | x - fauna | 46 | NA |
| Nickel | 18.8 | 7 | 7 | 20.9 | x - fauna | 0.9 | 39.4 | 5 | 12 | 160 | x - fauna | 0.2 | NA |
| Potassium | 1380 | 6 | 7 | NB | NB | | 6190 | 10 | 12 | 53000 | e* | 0.1 | NA |
| Selenium | ND | | 7 | NB | NB | | NA | | | 5.0 | x - fauna | | NA |
| Silver | 0.86 | 1 | 7 | 1.0 | x - fauna | 0.9 | NA | | | 0.0001 | x - fauna | | NA |

Table 4. Comparison of maximum concentrations with EPA Region III BTAG screening levels: Fire Training Area.

| Contaminant | Sediment (ug/kg organics, mg/kg metals) Maximum Sediment Concentration | Number of Detections | Total Number of Samples | Benchmark | Reference Source | Hazard Quotient | Water (ug/L) Maximum Water Concentration | Number of Detections | Total Number of Samples | Benchmark | Reference Source | Hazard Quotient | Soil Maximum Concentration |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sodium | 700 | 2 | 7 | NB | NB | | 14800 | 12 | 12 | 680000 | e* | 0.02 | NA |
| Vanadium | 13.2 | 7 | 7 | NB | NB | | 533 | 4 | 12 | 10000 | x - fauna | 0.1 | NA |
| Zinc | 42.2 | 7 | 7 | 150 | x - fauna | 2.0 | 379 | 12 | 12 | 110 | x- fauna | 3.4 | NA |

NB = No benchmark
NA=Not analyzed
ND=Not detected
a = Long et al. 1995 (ER-L)
b = Long and Morgan 1990 (ER-L)
c = Persuad et al. 1992 (LEL)
d = USEPA AWQC 1992 (Chronic Criteria)
e = Suter and Mabrey 1994 (SCV)
e* = Suter and Mabrey 1994 (LCV)
x - fauna = Region III BTAG Screening Level for fauna (lowest of flora and fauna chosen)
x - flora = Region III BTAG Screening Level for flora (lowest of flora and fauna chosen)
ug/kg=micrograms per kilogram (ppb)
ug/L = micrograms per liter (ppb)
mg/L = milligrams per liter (ppm)
HQ = Hazard Quotient (=maximum concentration divided by benchmark)

Table 4. Comparison of maximum concentrations with EPA Region III BTAG screening levels: Fire Training Area.

| Contaminant | Soil (ug/kg) Number of Detections | Total Number of Samples | Benchmark | Reference Source | Hazard Quotient |
|---|---|---|---|---|---|
| **Low Molecular Weight PAHs** | | | | | |
| Anthracene | | | 100 | x - fauna | |
| Phenanthrene | | | 100 | x - fauna | |
| Total Low Molecular Weight PAHs | | | NB | NB | |
| **High Molecular Weight PAHs** | | | | | |
| Benzo(a)anthracene | | | 100 | x - fauna | |
| Benzo(a)pyrene | | | 100 | x - fauna | |
| Benzo(b)fluoranthene | | | 100 | x - fauna | |
| Benzo(g,h,i)perylene | | | 100 | x - fauna | |
| Benzo(k)fluoranthene | | | 100 | x - fauna | |
| Chrysene | | | 100 | x - fauna | |
| Fluoranthene | | | 100 | x - fauna | |
| Indeno(1,2,3-c,d)pyrene | | | 100 | x - fauna | |
| Pyrene | | | 100 | x - fauna | |
| Total High Molecular Weight PAHs | | | NB | NB | |
| Total PAHs | | | NB | NB | |
| **Other Semi-Volatile Compounds** | | | | | |
| bis(2-ethylhexyl)phthalate | | | NB | NB | |
| Butylbenzylphthalate | | | NB | NB | |
| Diethylphthalate | | | NB | NB | |
| Di-n-butylphthalate | | | NB | NB | |
| **Volatile Organic Compounds** | | | | | |
| Acetone | | | NB | NB | |
| Carbon Disulfide | | | NB | NB | |
| Toluene | | | 100 | x - fauna | |
| **Pesticides/PCB** | | | | | |
| 4,4'-DDD | 1 | 4 | 100 | x - fauna | 0.04 |
| 4,4'-DDE | 3 | 4 | 100 | x - fauna | 0.4 |
| 4,4'-DDT | 3 | 4 | 100 | x - fauna | 0.4 |
| **Metals** | | | | | |
| Aluminum | | | 1 | x - flora | |
| Antimony | | | 0.48 | x - flora | |
| Arsenic (total) | | | 328 | x - flora | |
| Barium | | | 440 | x - fauna | |
| Beryllium | | | 0.02 | x - flora | |
| Cadmium | | | 2.5 | x - flora | |
| Calcium | | | NB | NB | |
| Chromium (total) | | | 0.0075 | x - fauna | |
| Cobalt | | | 100 | x - flora | |
| Copper | | | 15 | x - flora | |
| Cyanide | | | 0.005 | x - fauna | |
| Iron | | | 12 | x - fauna | |
| Lead | | | 0.01 | x - fauna | |
| Magnesium | | | 4400 | x - fauna | |
| Manganese | | | 330 | x - fauna | |
| Mercury | | | 0.058 | x - fauna | |
| Nickel | | | 2 | x - flora | |
| Potassium | | | NB | NB | |
| Selenium | | | 1.8 | x - fauna | |
| Silver | | | 0.0000098 | x - flora | |

Table 4. Comparison of maximum concentrations with EPA Region III BTAG screening levels: Fire Training Area.

| | Soil (ug/kg) | | | | |
|---|---|---|---|---|---|
| Contaminant | Number of Detections | Total Number of Samples | Benchmark | Reference Source | Hazard Quotient |
| Sodium | | | NB | NB | |
| Vanadium | | | 0.5 | x - flora | |
| Zinc | | | 10 | x - flora | |
| | | | | | |
| NB = No benchmark | | | | | |
| NA=Not analyzed | | | | | |
| ND=Not detected | | | | | |
| a = Long et al. 1995 (ER-L) | | | | | |
| b = Long and Morgan 1990 (ER-L) | | | | | |
| c = Persuad et al. 1992 (LEL) | | | | | |
| d = USEPA AWQC 1992 (Chronic Criteria) | | | | | |
| e = Suter and Mabrey 1994 (SCV) | | | | | |
| e' = Suter and Mabrey 1994 (LCV) | | | | | |
| x - fauna = Region III BTAG Screening Level for fauna (lowest of flora and fauna chosen) | | | | | |
| x - flora = Region III BTAG Screening Level for flora (lowest of flora and fauna chosen) | | | | | |
| ug/kg=micrograms per kilogram (ppb) | | | | | |
| ug/L = micrograms per liter (ppb) | | | | | |
| mg/L = milligrams per liter (ppm) | | | | | |
| HQ = Hazard Quotient (=maximum concentration divided by benchmark) | | | | | |
| | | | | | |
| | | | | | |

Table 5. Conservative food chain screening analysis for the Old Landfill: Kingfisher.

| Chemical | Maximum Conc. (mg/kg) | BAF | Conc. in Fish (mg/kg) | Conc. from Sediment (mg/kg) | Ingestion Rate (kg/day) | Water Conc. (mg/kg) | Water Ingestion (kg/day) | AJF | Body Weight (1/kg) | Dose (mg/kg/day) | LOAEL (mg/kg/day) | HQ based on LOAEL | NOAEL (mg/kg/day) | HQ based on NOAEL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PAHs** | | | | | | | | | | | | | | |
| 2-methylnaphthalene | 0.25 | 1 | 0.2 | 0.0004 | 0.06 | 0.000 | 0.012 | 1 | 8.85 | 0.1 | 100 | 0.001 | 10 | 0.01 |
| Acenaphthene | 0.090 | 1 | 0.1 | 0.0002 | 0.06 | 0.001 | 0.012 | 1 | 8.85 | 0.05 | 100 | 0.0005 | 10 | 0.005 |
| Acenaphthylene | 7.5 | 1 | 7.5 | 0.01 | 0.06 | 0.000 | 0.012 | 1 | 8.85 | 4.0 | 100 | 0.04 | 10 | 0.4 |
| Anthracene | 13.5 | 1 | 13.6 | 0.02 | 0.06 | 0.000 | 0.012 | 1 | 8.85 | 7.2 | 100 | 0.1 | 10 | 0.7 |
| Fluorene | 6.5 | 1 | 6.6 | 0.01 | 0.06 | 0.003 | 0.012 | 1 | 8.85 | 3.5 | 100 | 0.03 | 10 | 0.3 |
| Naphthalene | 0.85 | 1 | 0.8 | 0.001 | 0.06 | 0.000 | 0.012 | 1 | 8.85 | 0.5 | 100 | 0.005 | 10 | 0.05 |
| Phenanthrene | 60 | 1 | 59.9 | 0.1 | 0.06 | 0.010 | 0.012 | 1 | 8.85 | 31.9 | 100 | 0.3 | 10 | 3.2 |
| Benzo(a)anthracene | 24 | 1 | 23.6 | 0.04 | 0.06 | 0.000 | 0.012 | 1 | 8.85 | 12.5 | 100 | 0.1 | 10 | 1.2 |
| Benzo(a)pyrene | 27 | 1 | 27.0 | 0.05 | 0.06 | 0.000 | 0.012 | 1 | 8.85 | 14.3 | 100 | 0.1 | 10 | 1.4 |
| Benzo(b)fluoranthene | 37 | 1 | 36.9 | 0.1 | 0.06 | 0.000 | 0.012 | 1 | 8.85 | 19.6 | 100 | 0.2 | 10 | 2.0 |
| Benzo(g,h,i)perylene | 18 | 1 | 18.0 | 0.03 | 0.06 | 0.000 | 0.012 | 1 | 8.85 | 9.6 | 100 | 0.1 | 10 | 1.0 |
| Benzo(k)fluoranthene | 17.5 | 1 | 17.5 | 0.03 | 0.06 | 0.000 | 0.012 | 1 | 8.85 | 9.3 | 100 | 0.1 | 10 | 0.9 |
| Chrysene | 27.5 | 1 | 27.5 | 0.05 | 0.06 | 0.003 | 0.012 | 1 | 8.85 | 14.6 | 100 | 0.1 | 10 | 1.5 |
| Dibenz(a,h)anthracene | 4.6 | 1 | 4.5 | 0.01 | 0.06 | 0.000 | 0.012 | 1 | 8.85 | 2.4 | 100 | 0.02 | 10 | 0.2 |
| Fluoranthene | 60 | 1 | 59.9 | 0.1 | 0.06 | 0.008 | 0.012 | 1 | 8.85 | 31.9 | 100 | 0.3 | 10 | 3.2 |
| Indeno(1,2,3-c,d)pyrene | 19 | 1 | 19.0 | 0.03 | 0.06 | 0.000 | 0.012 | 1 | 8.85 | 10.1 | 100 | 0.1 | 10 | 1.0 |
| Pyrene | 44.5 | 1 | 44.4 | 0.1 | 0.06 | 0.005 | 0.012 | 1 | 8.85 | 23.6 | 100 | 0.2 | 10 | 2.4 |
| **Other Semivolatiles** | | | | | | | | | | | | | | |
| Carbon disulfide | 0.005 | 1 | 0.0 | 0.00001 | 0.06 | 0.290 | 0.012 | 1 | 8.85 | 0.03 | NA | | NA | |
| Carbazole | 0.055 | 1 | 0.1 | 0.00009 | 0.06 | 0.000 | 0.012 | 1 | 8.85 | 0.03 | NA | | NA | |
| Dibenzofuran | 3.3 | 1 | 3.3 | 0.01 | 0.06 | 0.000 | 0.012 | 1 | 8.85 | 1.8 | NA | | NA | |
| Diethylphthalate | 0.65 | 1 | 0.6 | 0.001 | 0.06 | 0.430 | 0.012 | 1 | 8.85 | 0.39 | NA | | NA | |
| **Volatiles** | | | | | | | | | | | | | | |
| Acetone | 0.000 | 1 | 0.0 | 0.0000 | 0.06 | 0.027 | 0.012 | 1 | 8.85 | 0.003 | NA | | NA | |
| Ethylbenzene | 0.09 | 1 | 0.1 | 0.0002 | 0.06 | 0.026 | 0.012 | 1 | 8.85 | 0.1 | NA | | NA | |
| Xylenes | 0.000 | 1 | 0.0 | 0.0000 | 0.06 | 0.124 | 0.012 | 1 | 8.85 | 0.0 | NA | | NA | |
| **Organochlorines** | | | | | | | | | | | | | | |
| 4,4'-DDD | 0.11 | 1 | 0.1 | 0.0002 | 0.06 | 0.001 | 0.012 | 1 | 8.85 | 0.1 | 4 | 0.01 | 1.25 | 0.05 |
| 4,4'-DDE | 0.1 | 1 | 0.1 | 0.0002 | 0.06 | 0.0003 | 0.012 | 1 | 8.85 | 0.1 | 4 | 0.01 | 1.25 | 0.04 |
| 4,4'-DDT | 0.22 | 1 | 0.2 | 0.0004 | 0.06 | 0.0008 | 0.012 | 1 | 8.85 | 0.1 | 4 | 0.03 | 1.25 | 0.1 |
| Aldrin | 0.00125 | 1 | 0.0 | 0.000002 | 0.06 | 0.000 | 0.012 | 1 | 8.85 | 0.001 | NA | | NA | |
| alpha-chlordane | 0.14 | 1 | 0.1 | 0.0002 | 0.06 | 0.000 | 0.012 | 1 | 8.85 | 0.1 | 0.19 | 0.4 | 0.019 | 3.9 |
| gamma-chlordane | 0.205 | 1 | 0.2 | 0.0003 | 0.06 | 0.000 | 0.025 | 1 | 8.85 | 0.1 | 0.19 | 0.6 | 0.019 | 5.7 |
| Methoxychlor | NA | 1 | | | 0.06 | 0.0003 | 0.025 | 1 | 8.85 | 0.0001 | NA | | NA | |
| **Metals** | | | | | | | | | | | | | | |
| Aluminum | 4840 | 1 | 4831.8 | 8.2 | 0.06 | 399 | 0.012 | 1 | 8.85 | 2612 | 165 | 16 | 84 | 31 |
| Antimony | 9.0 | 1 | 8.9 | 0.02 | 0.06 | 0.059 | 0.012 | 1 | 8.85 | 4.8 | NA | | NA | |
| Beryllium | 1.7 | 1 | 1.6 | 0.003 | 0.06 | 0.041 | 0.012 | 1 | 8.85 | 0.9 | NA | | NA | |
| Cadmium | 1.6 | 1 | 1.5 | 0.003 | 0.06 | 0.025 | 0.012 | 1 | 8.85 | 0.8 | 3.31 | 0.2 | 0.33 | 2.5 |
| Chromium (total) | 24.7 | 1 | 24.7 | 0.04 | 0.06 | 0.532 | 0.012 | 1 | 8.85 | 13.2 | 277.8 | 0.05 | 27.8 | 0.5 |
| Copper | 26.2 | 1 | 26.1 | 0.04 | 0.06 | 0.749 | 0.012 | 1 | 8.85 | 14.0 | 2.35 | 5.9 | 0.235 | 59 |
| Cyanide | 2.1 | 1 | 2.0 | 0.003 | 0.06 | 0.00 | 0.012 | 1 | 8.85 | 1.1 | NA | | NA | |
| Iron | 104000 | 1 | 103823 | 177 | 0.06 | 833 | 0.012 | 1 | 8.85 | 55312 | NA | | NA | |
| Lead | 193.5 | 1 | 193 | 0.3 | 0.06 | 1.8 | 0.012 | 1 | 8.85 | 103 | 3.0 | 34 | 0.3 | 343 |
| Magnesium | 3325 | 1 | 3319 | 5.7 | 0.06 | 121 | 0.012 | 1 | 8.85 | 1778 | NA | | NA | |
| Manganese | 2800 | 1 | 2795 | 4.8 | 0.06 | 15.6 | 0.012 | 1 | 8.85 | 1488 | NA | | NA | |
| Mercury | 0.095 | 1 | 0.1 | 0.0002 | 0.06 | 0.0008 | 0.012 | 1 | 8.85 | 0.05 | 0.12 | 0.42 | 0.012 | 4.2 |
| Nickel | 28.6 | 1 | 28.5 | 0.05 | 0.06 | 0.614 | 0.012 | 1 | 8.85 | 15.2 | NA | | NA | |
| Potassium | 1285 | 1 | 1282.8 | 2.2 | 0.06 | 60.3 | 0.012 | 1 | 8.85 | 689 | NA | | NA | |
| Selenium | 0 | 1 | 0.0 | 0.000 | 0.06 | 0.022 | 0.012 | 1 | 8.85 | 0.0 | NA | | NA | |
| Silver | NA | 1 | 0.0 | 0.0 | 0.06 | 0.003 | 0.012 | 1 | 8.85 | 0.0004 | NA | | NA | |
| Sodium | 1410 | 1 | 1407.6 | 2.4 | 0.06 | 28.1 | 0.012 | 1 | 8.85 | 752 | NA | | NA | |
| Zinc | 93 | 1 | 92.8 | 0.2 | 0.06 | 2.98 | 0.012 | 1 | 8.85 | 50 | 139 | 0.4 | 13.9 | 3.6 |

% moisture not available, used 50% moisture as an estimate

Table 6. Conservative food chain screening analysis for the Old Landfill. Raccoon.

| Chemical | Maximum Conc. (mg/kg) | BAF | Conc. in Fish (mg/kg) | Conc. from Sediment (mg/kg) | Ingestion Rate (kg/day) | Water Conc. (mg/kg) | Water Ingestion (kg/day) | AUF | Body Weight (1/kg) | Dose (mg/kg/day) | LOAEL (mg/kg/day) | HQ based on LOAEL | NOAEL (mg/kg/day) | HQ based on NOAEL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PAHs** | | | | | | | | | | | | | | |
| 2-methylnaphthalene | 0.25 | 1 | 0.2 | 0.02 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 0.1 | 2.6 | 0.02 | 1.3 | 0.05 |
| Acenaphthene | 0.090 | 1 | 0.1 | 0.01 | 0.5 | 0.001 | 0.025 | 1 | 0.5 | 0.02 | 2.6 | 0.01 | 1.3 | 0.02 |
| Acenaphthylene | 7.5 | 1 | 7 | 0.7 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 1.9 | 2.6 | 0.7 | 1.3 | 1.4 |
| Anthracene | 13.5 | 1 | 12 | 1.3 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 3.4 | 2.6 | 1.3 | 1.3 | 2.6 |
| Fluorene | 6.5 | 1 | 6 | 0.6 | 0.5 | 0.003 | 0.025 | 1 | 0.5 | 1.6 | 2.6 | 0.6 | 1.3 | 1.3 |
| Naphthalene | 0.85 | 1 | 1 | 0.1 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 0.2 | 2.6 | 0.1 | 1.3 | 0.2 |
| Phenanthrene | 60 | 1 | 54 | 5.6 | 0.5 | 0.010 | 0.025 | 1 | 0.5 | 15.0 | 2.6 | 5.8 | 1.3 | 12 |
| Benzo(a)anthracene | 23.5 | 1 | 21 | 2.2 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 5.9 | 2.6 | 2.3 | 1.3 | 4.5 |
| Benzo(a)pyrene | 27 | 1 | 24 | 2.5 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 6.8 | 2.6 | 2.6 | 1.3 | 5.2 |
| Benzo(b)fluoranthene | 37 | 1 | 34 | 3.5 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 9.3 | 2.6 | 3.6 | 1.3 | 7.1 |
| Benzo(g,h,i)perylene | 18 | 1 | 16 | 1.7 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 4.5 | 2.6 | 1.7 | 1.3 | 3.5 |
| Benzo(k)fluoranthene | 17.5 | 1 | 16 | 1.6 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 4.4 | 2.6 | 1.7 | 1.3 | 3.4 |
| Chrysene | 27.5 | 1 | 25 | 2.6 | 0.5 | 0.003 | 0.025 | 1 | 0.5 | 6.9 | 2.6 | 2.6 | 1.3 | 5.3 |
| Dibenz(a,h)anthracene | 4.55 | 1 | 4.1 | 0.4 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 1.1 | 2.6 | 0.4 | 1.3 | 0.9 |
| Fluoranthene | 60 | 1 | 54 | 5.6 | 0.5 | 0.008 | 0.025 | 1 | 0.5 | 15.0 | 2.6 | 5.8 | 1.3 | 12 |
| Indeno(1,2,3-c,d)pyrene | 19 | 1 | 17 | 1.8 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 4.8 | 2.6 | 1.8 | 1.3 | 3.7 |
| Pyrene | 44.5 | 1 | 40 | 4.2 | 0.5 | 0.005 | 0.025 | 1 | 0.5 | 11.1 | 2.6 | 4.3 | 1.3 | 8.6 |
| **Other Semivolatiles** | | | | | | | | | | | | | | |
| Carbon disulfide | 0.005 | 1 | 0.005 | 0.0005 | 0.5 | 0.290 | 0.025 | 1 | 0.5 | 0.0 | NA | | NA | |
| Carbazole | 0.055 | 1 | 0.05 | 0.005 | 0.5 | 0.000 | 0.025 | | | | | | | |
| Dibenzofuran | 3.3 | 1 | 3.0 | 0.31 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 0.8 | NA | | NA | |
| Diethylphthalate | 0.65 | 1 | 0.6 | 0.06 | 0.5 | 0.430 | 0.025 | 1 | 0.5 | 0.2 | NA | | NA | |
| **Volatiles** | | | | | | | | | | | | | | |
| Acetone | 0.185 | 1 | 0.17 | 0.017 | 0.5 | 0.027 | 0.025 | 1 | 0.5 | 0.05 | NA | | NA | |
| Ethylbenzene | 0.09 | 1 | 0.082 | 0.008 | 0.5 | 0.026 | 0.025 | 1 | 0.5 | 0.02 | NA | | NA | |
| Xylenes | 0 | 1 | 0.00 | 0.00 | 0.5 | 0.124 | 0.025 | 1 | 0.5 | 0.0 | NA | | NA | |
| **Organochlorines** | | | | | | | | | | | | | | |
| 4,4'-DDD | 0.11 | 1 | 0.10 | 0.01 | 0.5 | 0.001 | 0.025 | 1 | 0.5 | 0.03 | 1.25 | 0.02 | 0.125 | 0.2 |
| 4,4'-DDE | 0.1 | 1 | 0.09 | 0.01 | 0.5 | 0.0003 | 0.025 | 1 | 0.5 | 0.03 | 1.25 | 0.02 | 0.125 | 0.2 |
| 4,4'-DDT | 0.22 | 1 | 0.20 | 0.02 | 0.5 | 0.0008 | 0.025 | 1 | 0.5 | 0.06 | 1.25 | 0.04 | 0.125 | 0.4 |
| Aldrin | 0.00125 | 1 | 0.001 | 0.0001 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 0.000 | NA | | NA | |
| alpha-chlordane | 0.14 | 1 | 0.13 | 0.01 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 0.04 | 1.88 | 0.02 | 0.188 | 0.2 |
| gamma-chlordane | 0.21 | 1 | 0.19 | 0.02 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 0.05 | 1.88 | 0.03 | 0.188 | 0.3 |
| Methoxychlor | NA | 1 | 0 | 0 | 0.5 | 0.0003 | 0.025 | 1 | 0.5 | 0.000004 | NA | | NA | |
| **Metals** | | | | | | | | | | | | | | |
| Aluminum | 4840 | 1 | 4385 | 455 | 0.5 | 399 | 0.025 | 1 | 0.5 | 1215.0 | 55 | 22 | 5.5 | 221 |
| Antimony | 9.0 | 1 | 8 | 0.8 | 0.5 | 0.059 | 0.025 | 1 | 8.85 | 39.6 | NA | | NA | |
| Beryllium | 1.7 | 1 | 1.5 | 0.16 | 0.5 | 0.041 | 0.025 | 1 | 0.5 | 0.4 | NA | | NA | |
| Cadmium | 1.6 | 1 | 1.4 | 0.15 | 0.5 | 0.025 | 0.025 | 1 | 0.5 | 0.4 | 7.5 | 0.1 | 0.75 | 0.5 |
| Chromium (total) | 24.7 | 1 | 22 | 2.3 | 0.5 | 0.532 | 0.025 | 1 | 0.5 | 6.2 | 1.7 | 3.6 | 0.17 | 36 |
| Copper | 26.2 | 1 | 24 | 2.5 | 0.5 | 0.749 | 0.025 | 1 | 0.5 | 6.5 | 10 | 0.7 | 1 | 6.5 |
| Cyanide | 2.1 | 1 | 2 | 0.19 | 0.5 | 0.00 | 0.012 | 1 | 8.85 | 9.1 | NA | | NA | |
| Iron | 104000 | 1 | 94224 | 9776 | 0.5 | 833 | 0.025 | 1 | 0.5 | 25010 | NA | | NA | |
| Lead | 193.5 | 1 | 175 | 18 | 0.5 | 1.8 | 0.025 | 1 | 0.5 | 48 | 1.5 | 32 | 0.15 | 323 |
| Magnesium | 3325 | 1 | 3012 | 313 | 0.5 | 121 | 0.025 | 1 | 0.5 | 833 | NA | | NA | |
| Manganese | 2800 | 1 | 2537 | 263 | 0.5 | 15.6 | 0.025 | 1 | 0.5 | 700 | 13 | 54 | 1.3 | 539 |
| Mercury | 0.095 | 1 | 0.09 | 0.009 | 0.5 | 0.0008 | 0.025 | 1 | 0.5 | 0.02 | 0.1 | 0.2 | 0.01 | 2.4 |
| Nickel | 28.6 | 1 | 26 | 2.7 | 0.5 | 0.614 | 0.025 | 1 | 0.5 | 7.1 | 625 | 0.01 | 62.5 | 0.1 |
| Potassium | 1285 | 1 | 1164 | 120.8 | 0.5 | 60.3 | 0.025 | 1 | 0.5 | 322.0 | NA | | NA | |
| Selenium | 0 | 1 | 0 | 0.00 | 0.5 | 0.022 | 0.025 | 1 | 0.5 | 0.0 | NA | | NA | |
| Silver | NA | 1 | 0 | 0 | 0.5 | 0.003 | 0.025 | 1 | 0.5 | 0.00004 | NA | | NA | |
| Sodium | 1410 | 1 | 1277 | 133 | 0.5 | 28.1 | 0.025 | 1 | 0.5 | 352.85 | NA | | NA | |
| Zinc | 93 | 1 | 84 | 8.7 | 0.5 | 2.98 | 0.025 | 1 | 0.5 | 23.3 | 250 | 0.1 | 25 | 0.9 |

% moisture not available, used 50% moisture as an estimate

Table 6. Conservative food chain screening analysis for the Old Landfill. Raccoon.

| Chemical | Maximum Conc. (mg/kg) | BAF | Conc. In Fish (mg/kg) | Conc. from Sediment (mg/kg) | Ingestion Rate (kg/day) | Water Conc. (mg/kg) | Water Ingestion (kg/day) | AUF | Body Weight (1/kg) | Dose (mg/kg/day) | LOAEL (mg/kg/day) | HQ based on LOAEL | NOAEL (mg/kg/day) | HQ based on NOAEL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PAHs | | | | | | | | | | | | | | |
| 2-methylnaphthalene | 0.25 | 1 | 0.2 | 0.02 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 0.1 | 2.6 | 0.02 | 1.3 | 0.05 |
| Acenaphthene | 0.090 | 1 | 0.1 | 0.01 | 0.5 | 0.001 | 0.025 | 1 | 0.5 | 0.02 | 2.6 | 0.01 | 1.3 | 0.02 |
| Acenaphthylene | 7.5 | 1 | 7 | 0.7 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 1.9 | 2.6 | 0.7 | 1.3 | 1.4 |
| Anthracene | 13.5 | 1 | 12 | 1.3 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 3.4 | 2.6 | 1.3 | 1.3 | 2.6 |
| Fluorene | 6.5 | 1 | 6 | 0.6 | 0.5 | 0.003 | 0.025 | 1 | 0.5 | 1.6 | 2.6 | 0.6 | 1.3 | 1.3 |
| Naphthalene | 0.85 | 1 | 1 | 0.1 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 0.2 | 2.6 | 0.1 | 1.3 | 0.2 |
| Phenanthrene | 60 | 1 | 54 | 5.6 | 0.5 | 0.010 | 0.025 | 1 | 0.5 | 15.0 | 2.6 | 5.8 | 1.3 | 12 |
| Benzo(a)anthracene | 23.5 | 1 | 21 | 2.2 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 5.9 | 2.6 | 2.3 | 1.3 | 4.5 |
| Benzo(a)pyrene | 27 | 1 | 24 | 2.5 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 6.8 | 2.6 | 2.6 | 1.3 | 5.2 |
| Benzo(b)fluoranthene | 37 | 1 | 34 | 3.5 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 9.3 | 2.6 | 3.6 | 1.3 | 7.1 |
| Benzo(g,h,i)perylene | 18 | 1 | 16 | 1.7 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 4.5 | 2.6 | 1.7 | 1.3 | 3.5 |
| Benzo(k)fluoranthene | 17.5 | 1 | 16 | 1.6 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 4.4 | 2.6 | 1.7 | 1.3 | 3.4 |
| Chrysene | 27.5 | 1 | 25 | 2.6 | 0.5 | 0.003 | 0.025 | 1 | 0.5 | 6.9 | 2.6 | 2.6 | 1.3 | 5.3 |
| Dibenz(a,h)anthracene | 4.65 | 1 | 4.1 | 0.4 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 1.1 | 2.6 | 0.4 | 1.3 | 0.9 |
| Fluoranthene | 60 | 1 | 54 | 5.6 | 0.5 | 0.008 | 0.025 | 1 | 0.5 | 15.0 | 2.6 | 5.8 | 1.3 | 12 |
| Indeno(1,2,3-cd)pyrene | 19 | 1 | 17 | 1.8 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 4.8 | 2.6 | 1.8 | 1.3 | 3.7 |
| Pyrene | 44.5 | 1 | 40 | 4.2 | 0.5 | 0.005 | 0.025 | 1 | 0.5 | 11.1 | 2.6 | 4.3 | 1.3 | 8.6 |
| Other Semivolatiles | | | | | | | | | | | | | | |
| Carbon disulfide | 0.005 | 1 | 0.005 | 0.0005 | 0.5 | 0.290 | 0.025 | 1 | 0.5 | 0.0 | NA | | NA | |
| Carbazole | 0.055 | 1 | 0.05 | 0.005 | 0.5 | 0.000 | 0.025 | | | | | | | |
| Dibenzofuran | 3.3 | 1 | 3.0 | 0.31 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 0.8 | NA | | NA | |
| Diethylphthalate | 0.65 | 1 | 0.6 | 0.06 | 0.5 | 0.430 | 0.025 | 1 | 0.5 | 0.2 | NA | | NA | |
| Volatiles | | | | | | | | | | | | | | |
| Acetone | 0.185 | 1 | 0.17 | 0.017 | 0.5 | 0.027 | 0.025 | 1 | 0.5 | 0.05 | NA | | NA | |
| Ethylbenzene | 0.09 | 1 | 0.082 | 0.008 | 0.5 | 0.026 | 0.025 | 1 | 0.5 | 0.02 | NA | | NA | |
| Xylenes | 0 | 1 | 0.00 | 0.00 | 0.5 | 0.124 | 0.025 | 1 | 0.5 | 0.0 | NA | | NA | |
| Organochlorines | | | | | | | | | | | | | | |
| 4,4'-DDD | 0.11 | 1 | 0.10 | 0.01 | 0.5 | 0.001 | 0.025 | 1 | 0.5 | 0.03 | 1.25 | 0.02 | 0.125 | 0.2 |
| 4,4'-DDE | 0.1 | 1 | 0.09 | 0.01 | 0.5 | 0.0003 | 0.025 | 1 | 0.5 | 0.03 | 1.25 | 0.02 | 0.125 | 0.2 |
| 4,4'-DDT | 0.22 | 1 | 0.20 | 0.02 | 0.5 | 0.0008 | 0.025 | 1 | 0.5 | 0.06 | 1.25 | 0.04 | 0.125 | 0.4 |
| Aldrin | 0.00125 | 1 | 0.001 | 0.0001 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 0.000 | NA | | NA | |
| alpha-chlordane | 0.14 | 1 | 0.13 | 0.01 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 0.04 | 1.88 | 0.02 | 0.188 | 0.2 |
| gamma-chlordane | 0.21 | 1 | 0.19 | 0.02 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 0.05 | 1.88 | 0.03 | 0.188 | 0.3 |
| Methoxychlor | NA | 1 | 0 | 0 | 0.5 | 0.0003 | 0.025 | 1 | 0.5 | 0.000004 | NA | | NA | |
| Metals | | | | | | | | | | | | | | |
| Aluminum | 4840 | 1 | 4385 | 455 | 0.5 | 399 | 0.025 | 1 | 0.5 | 1215.0 | 55 | 22 | 5.5 | 221 |
| Antimony | 9.0 | 1 | 8 | 0.8 | 0.5 | 0.059 | 0.025 | 1 | 8.85 | 39.6 | NA | | NA | |
| Beryllium | 1.7 | 1 | 1.5 | 0.16 | 0.5 | 0.041 | 0.025 | 1 | 0.5 | 0.4 | NA | | NA | |
| Cadmium | 1.6 | 1 | 1.4 | 0.15 | 0.5 | 0.025 | 0.025 | 1 | 0.5 | 0.4 | 7.5 | 0.1 | 0.75 | 0.5 |
| Chromium (total) | 24.7 | 1 | 22 | 2.3 | 0.5 | 0.532 | 0.025 | 1 | 0.5 | 6.2 | 1.7 | 3.6 | 0.17 | 36 |
| Copper | 26.2 | 1 | 24 | 2.5 | 0.5 | 0.749 | 0.025 | 1 | 0.5 | 6.5 | 10 | 0.7 | 1 | 6.5 |
| Cyanide | 2.1 | 1 | 2 | 0.19 | 0.5 | 0.00 | 0.012 | 1 | 8.85 | 9.1 | NA | | NA | |
| Iron | 104000 | 1 | 94224 | 9776 | 0.5 | 833 | 0.025 | 1 | 0.5 | 26010 | NA | | NA | |
| Lead | 193.5 | 1 | 175 | 18 | 0.5 | 1.8 | 0.025 | 1 | 0.5 | 48 | 1.5 | 32 | 0.15 | 323 |
| Magnesium | 3325 | 1 | 3012 | 313 | 0.5 | 121 | 0.025 | 1 | 0.5 | 833 | NA | | NA | |
| Manganese | 2800 | 1 | 2537 | 263 | 0.5 | 15.6 | 0.025 | 1 | 0.5 | 700 | 13 | 54 | 1.3 | 539 |
| Mercury | 0.095 | 1 | 0.09 | 0.009 | 0.5 | 0.0008 | 0.025 | 1 | 0.5 | 0.02 | 0.1 | 0.2 | 0.01 | 2.4 |
| Nickel | 28.6 | 1 | 26 | 2.7 | 0.5 | 0.614 | 0.025 | 1 | 0.5 | 7.1 | 625 | 0.01 | 62.5 | 0.1 |
| Potassium | 1285 | 1 | 1164 | 120.8 | 0.5 | 60.3 | 0.025 | 1 | 0.5 | 322.0 | NA | | NA | |
| Selenium | 0 | 1 | 0 | 0.00 | 0.5 | 0.022 | 0.025 | 1 | 0.5 | 0.0 | NA | | NA | |
| Silver | NA | 1 | 0 | 0 | 0.5 | 0.003 | 0.025 | 1 | 0.5 | 0.00004 | NA | | NA | |
| Sodium | 1410 | 1 | 1277 | 133 | 0.5 | 28.1 | 0.025 | 1 | 0.5 | 352.85 | NA | | NA | |
| Zinc | 93 | 1 | 84 | 8.7 | 0.5 | 2.98 | 0.025 | 1 | 0.5 | 23.3 | 250 | 0.1 | 25 | 0.9 |
| % moisture not available, used 50% moisture as an estimate | | | | | | | | | | | | | | |

Table 7. Conservative food chain screening analysis for the Fire Training Area: Kingfisher.

| Chemical | Maximum Conc. (mg/kg) | BAF | Conc. in Fish (mg/kg) | Conc. from Sediment (mg/kg) | Ingestion Rate (kg/day) | Water Conc. (mg/kg) | Water Ingestion (kg/day) | AUF | Body Weight (1/kg) | Dose (mg/kg/day) | LOAEL (mg/kg/day) | HQ based on LOAEL | NOAEL (mg/kg/day) | HQ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PAHs** | | | | | | | | | | | | | | |
| Phenanthrene | 0.13 | 1 | 0.1 | 0.0002 | 0.06 | 0.000 | 0.012 | 1 | 8.85 | 0.1 | 100 | 0.001 | 10 | 0.01 |
| Benzo(k)fluoranthene | 0.020 | 1 | 0.02 | 0.00003 | 0.06 | 0.000 | 0.012 | 1 | 8.85 | 0.0 | 100 | 0.0001 | 10 | 0.001 |
| | | | | | | | | | | | | | | |
| **Other Semivolatiles** | | | | | | | | | | | | | | |
| Butylbenzylphthalate | 0.055 | 1 | 0.1 | 0.0001 | 0.06 | 0.000 | 0.012 | 1 | 8.85 | 0.03 | NA | | NA | |
| | | | | | | | | | | | | | | |
| **Volatiles** | | | | | | | | | | | | | | |
| Carbon disulfide | NA | 1 | 0.0 | 0.00 | 0.06 | 0.002 | 0.012 | 1 | 8.85 | 0.0002 | NA | | NA | |
| | | | | | | | | | | | | | | |
| **Organochlorines** | | | | | | | | | | | | | | |
| 4,4'-DDD | 0.055 | 1 | 0.1 | 0.0001 | 0.06 | 0.014 | 0.012 | 1 | 8.85 | 0.03 | 1.25 | 0.02 | 0.125 | 0.2 |
| 4,4'-DDE | 0.24 | 1 | 0.2 | 0.0004 | 0.06 | 0.004 | 0.012 | 1 | 8.85 | 0.1 | 1.25 | 0.1 | 0.125 | 1.0 |
| 4,4'-DDT | 0.13 | 1 | 0.1 | 0.0002 | 0.06 | 0.016 | 0.012 | 1 | 8.85 | 0.1 | 1.25 | 0.1 | 0.125 | 0.5 |
| | | | | | | | | | | | | | | |
| **Metals** | | | | | | | | | | | | | | |
| Aluminum | 1855 | 1 | 1851.8 | 3.15 | 0.06 | 33.2 | 0.012 | 1 | 8.85 | 989 | 165 | 6.0 | 84 | 12 |
| Cadmium | 0.65 | 1 | 0.6 | 0.001 | 0.06 | 0.234 | 0.012 | 1 | 8.85 | 0.4 | 3.31 | 0.1 | 0.33 | 1.1 |
| Calcium | 432 | 1 | 430.8 | 0.73 | 0.06 | 190 | 0.012 | 1 | 8.85 | 249 | NA | | NA | |
| Chromium (total) | 4.55 | 1 | 4.5 | 0.01 | 0.06 | 0.081 | 0.012 | 1 | 8.85 | 2.4 | 277.8 | 0.01 | 27.8 | 0.1 |
| Copper | 4.4 | 1 | 4.4 | 0.01 | 0.06 | 0.435 | 0.012 | 1 | 8.85 | 2.4 | 2.35 | 1.0 | 0.235 | 10 |
| Iron | 13900 | 1 | 13876 | 23.6 | 0.06 | 1460 | 0.012 | 1 | 8.85 | 7536 | NA | | NA | |
| Lead | 17.8 | 1 | 17.7 | 0.03 | 0.06 | 0.498 | 0.012 | 1 | 8.85 | 9.5 | 3 | 3.2 | 0.3 | 32 |
| Manganese | 360 | 1 | 358.9 | 0.61 | 0.06 | 7.080 | 0.012 | 1 | 8.85 | 191.6 | NA | | NA | |
| Mercury | ND | 1 | 0.0 | 0.00 | 0.06 | 0.001 | 0.012 | 1 | 8.85 | 0.0001 | 0.12 | 0.0005 | 0.012 | 0.005 |
| Zinc | 21.1 | 1 | 21.1 | 0.04 | 0.06 | 0.379 | 0.012 | 1 | 8.85 | 11.2 | 139 | 0.1 | 13.9 | 0.8 |
| | | | | | | | | | | | | | | |
| % moisture not available, used 50% moisture as an estimate | | | | | | | | | | | | | | |

Table 8 Conservative food chain analysis for the Fire Training Area: Raccoon.

| Chemical | Maximum Conc. (mg/kg) | BAF | Conc. in Fish (mg/kg) | Conc. from Sediment (mg/kg) | Ingestion Rate (kg/day) | Water Conc. (mg/kg) | Water Ingestion (kg/day) | AUF | Body Weight (1/kg) | Dose (mg/kg/day) | LOAEL (mg/kg/day) | HQ based on LOAEL | NOAEL (mg/kg/day) | HQ based on NOAEL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PAHs** | | | | | | | | | | | | | | |
| Phenanthrene | 0.13 | 1 | 0.1 | 0.01 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 0.03 | 2.6 | 0.01 | 1.3 | 0.02 |
| Benzo(k)fluoranthene | 0.02 | 1 | 0.0 | 0.00 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 0.004 | 2.6 | 0.002 | 1.3 | 0.003 |
| **Other Semivolatiles** | | | | | | | | | | | | | | |
| Butylbenzylphthalate | 0.055 | 1 | 0.04 | 0.01 | 0.5 | 0.000 | 0.025 | 1 | 0.5 | 0.01 | NA | | NA | |
| **Volatiles** | | | | | | | | | | | | | | |
| Carbon disulfide | NA | 1 | 0.00 | 0.00 | 0.5 | 0.002 | 0.025 | 1 | 0.5 | 0.00002 | 70 | 0.0000004 | 11 | 0.000002 |
| **Organochlorines** | | | | | | | | | | | | | | |
| 4,4'-DDD | 0.055 | 1 | 0.05 | 0.01 | 0.5 | 0.014 | 0.025 | 1 | 0.5 | 0.01 | 4.0 | 0.003 | 1.0 | 0.01 |
| 4,4'-DDE | 0.24 | 1 | 0.22 | 0.02 | 0.5 | 0.004 | 0.025 | 1 | 0.5 | 0.06 | 4.0 | 0.02 | 1.0 | 0.06 |
| 4,4'-DDT | 0.13 | 1 | 0.11 | 0.01 | 0.5 | 0.016 | 0.025 | 1 | 0.5 | 0.03 | 4.0 | 0.008 | 1.0 | 0.03 |
| **Metals** | | | | | | | | | | | | | | |
| Aluminum | 1855 | 1 | 1680.63 | 174.4 | 0.5 | 33.2 | 0.025 | 1 | 0.5 | 464 | 55 | 8.4 | 5.5 | 84 |
| Cadmium | 0.65 | 1 | 0.59 | 0.1 | 0.5 | 0.234 | 0.025 | 1 | 0.5 | 0.2 | 7.5 | 0.02 | 0.75 | 0.2 |
| Calcium | 431.5 | 1 | 390.94 | 40.6 | 0.5 | 190 | 0.025 | 1 | 0.5 | 110 | NA | | NA | |
| Chromium (total) | 4.55 | 1 | 4.12 | 0.4 | 0.5 | 0.081 | 0.025 | 1 | 0.5 | 1.1 | 1.7 | 0.7 | 0.17 | 6.7 |
| Copper | 4.4 | 1 | 3.99 | 0.4 | 0.5 | 0.435 | 0.025 | 1 | 0.5 | 1.1 | 10 | 0.1 | 1 | 1.1 |
| Iron | 13900 | 1 | 12593.40 | 1307 | 0.5 | 1460 | 0.025 | 1 | 0.5 | 3493 | NA | | NA | |
| Lead | 17.8 | 1 | 16.13 | 1.7 | 0.5 | 0.498 | 0.025 | 1 | 0.5 | 4.5 | 1.5 | 3.0 | 0.15 | 30 |
| Manganese | 359.5 | 1 | 325.71 | 33.8 | 0.5 | 7.080 | 0.025 | 1 | 0.5 | 90 | 13 | 6.9 | 1.3 | 69 |
| Mercury | ND | 1 | 0.00 | 0.00 | 0.5 | 0.001 | 0.025 | 1 | 0.5 | 0.000007 | 0.1 | 0.00007 | 0.01 | 0.0007 |
| Zinc | 21.1 | 1 | 19.12 | 2.0 | 0.5 | 0.379 | 0.025 | 1 | 0.5 | 5.3 | 250 | 0.02 | 25 | 0.2 |
| % moisture not available, used 50% moisture as an estimate | | | | | | | | | | | | | | |

Table 9. Comparison of sediment contaminant concentrations with guidance values.

| Contaminant | >ER-L[a] | >TEL[b] | >ER-M[c] | >PEL[d] |
|---|---|---|---|---|
| **Old Landfill** | | | | |
| Total chlordane | 10/28 | 9/28 | 8/28 | 8/28 |
| Total DDT | 22/28 | 22/28 | 2/28 | 0/28 |
| Total PAHs | 6/28 | Not avail. | 1/28 | Not avail. |
| Arsenic | 0/28 | 0/28 | 0/28 | 0/28 |
| Cadmium | 0/28 | 0/28 | 0/28 | 0/28 |
| Chromium | 0/28 | 2/28 | 0/28 | 0/28 |
| Copper | 0/28 | 0/28 | 0/28 | 0/28 |
| Lead | 6/28 | 6/28 | 1/28 | 3/28 |
| Mercury | 1/28 | 1/28 | 0/28 | 0/28 |
| Nickel | 3/28 | 6/28 | 1/28 | 2/28 |
| Zinc | 1/28 | 1/28 | 0/28 | 0/28 |
| **Fire Training Area** | | | | |
| Total chlordane | 0/10 | 0/10 | 0/10 | 0/10 |
| Total DDT | 10/10 | 10/10 | 0/10 | 0/10 |
| Total PAHs | 0/10 | Not avail. | 0/10 | Not avail. |
| Arsenic | 0/7 | 0/7 | 0/7 | 0/7 |
| Cadmium | 0/7 | 0/7 | 0/7 | 0/7 |
| Chromium | 0/7 | 0/7 | 0/7 | 0/7 |
| Copper | 0/7 | 0/7 | 0/7 | 0/7 |
| Lead | 1/7 | 1/7 | 0/7 | 0/7 |
| Mercury | 0/7 | 0/7 | 0/7 | 0/7 |
| Nickel | 0/7 | 1/7 | 0/7 | 0/7 |
| Zinc | 0/7 | 0/7 | 0/7 | 0/7 |

[a] ER-L values (ppm dry weight): Total chlordane: 0.0005; Total DDT--0.003; Total PAH--4.00, As--33; Cd--5; Cr--80; Cu--70; Pb--35; Hg--0.15;; Ni--30; Zn--120 (Long and Morgan 1990).
[b] TEL values (ppm dry weight):Total chlordane: 0.0045; Total DDT--0.007; Total PAH--Not available; As--5.9; Cd--0.596; Cr--37.3; Cu--35.7; Pb--35; Hg--0.174; Ni--18; Zn--123 (Smith et al. 1996).
[c] ER-M values (ppm dry weight): Total chlordane: 0.006; Total DDT--0.350; Total PAH--35.00, As--85; Cd--9; Cr--145; Cu--390; Pb--110; Hg--1.3;; Ni--50; Zn--270 (Long and Morgan 1990).
[d] PEL values (ppm dry weight):Total chlordane: 0.0089; Total DDT--4.45; Total PAH--Not available; As--517; Cd--3.53; Cr--90; Cu--197; Pb--91.3; Hg--0.486; Ni--36; Zn--315 (Smith et al. 1996).

Table 10. Chemicals detected in exceedance of water quality criteria.

| Chemical | Freq. of Det. | Concentration exceeding criteria ($\mu g/L$) | Acute ($\mu g/L$) (a)-Maryland (b)-EPA | Chronic ($\mu g/L$) (a)-Maryland (b)-EPA |
|---|---|---|---|---|
| **Old Landfill** | | | | |
| 4,4'DDD | 2/29 | 1/29: 0.81 | 0.6 (b) | None listed |
| 4,4'-DDT | 1/29 | 1/29: 0.11 | 1.1 (a) | 0.001 (a) |
| methoxychlor | 1/29 | 1/29: 0.31 | None listed | 0.03 (b) |
| aluminum | 27/29 | 25/29: 399000, 65300, 22700, 15100, 11800, 5610, 4140, 3620, 3340, 2310, 2110, 1100, 1066, 879, 540, 418, 278, 213, 212, 208, 144, 111, 95.7, 94.9, 93.8 | 750 (b) | 87 (b) |
| antimony | 1/29 | 1/29: 58.7 | 88.0 (b) | 30.0 (b) |
| beryllium | 9/29 | 2/29: 40.5, 7.6 | 130 (b) | 5.3 (b) |
| cadmium | 2/29 | 2/29: 25.4, 21.1 | 3.9 (a) | 1.1 (a) |
| chromium (VI) | 10/29 | 7/29: 532, 201, 62.2, 39.1, 25.0, 19.3, 17.7 | 16.0 (a) | 11.0 (a) |
| copper | 12/29 | 8/12: 950, 216, 118, 115, 114, 82.5, 29.6, 26.8 | 18 (a) | 12 (a) |
| iron | 29/29 | 17/29: 833, 709, 449, 239, 168, 53.6, 48.4, 21.9, 14.3, 5.73, 4.88, 3.65, 3.49, 3.06, 1.34, 1.30, 1.27 (all mg/L) | None listed | 1.0 mg/L (b) |
| lead | 24/29 | 16/29: 1360, 656, 111, 66.4, 42.4, 32.2, 28.1, 16.0, 14.5, 9.8, 8.5, 8.0, 4.9, 4.3, 3.8, 3.6 | 82 (a) | 3.2 (a) |
| manganese | 29/29 | 21/29: 15,600, 5800, 5260, 4930, 2960, 2950, 2840, 2690, 1010, 784, 368, 308, 183, 173, 96.2, 88.0, 86.9, 66.6, 60.1, 56.4, 56.1 | None listed | 50.0 (b) |

| | | | | |
|---|---|---|---|---|
| mercury | 5/29 | 5/29: 0.81, 0.28, 0.28, 0.24, 0.20 | 2.4 (a) | 0.012 (a) |
| nickel | 10/29 | 2/29: 614, 277 | 1400 (a) | 160 (a) |
| selenium | 2/29 | 1/29: 22.4 | 20.0 (a) | 5.0 (a) |
| zinc | 25/29 | 5/29: 2980, 1570, 477, 158, 140 | 120 (a) | 110 (a) |
| **Fire Training Area** | | | | |
| 4,4'DDD | 4/12 | 3/12: 14.0, 2.1, 0.81 | 0.6 (b) | None listed |
| 4,4'-DDT | 1/12 | 1/12: 16.0 | 1.1 (a) | 0.001 (a) |
| aluminum | 12/12 | 10/12: 33200, 7720, 4420, 3540, 335, 157, 122, 107, 105, 98.7 | 750 (b) | 87 (b) |
| cadmium | 2/12 | 2/12: 234, 8.2 | 3.9 (a) | 1.1 (a) |
| chromium | 4/12 | 2/12: 80.9, 14.6 | 16.0 (a) | 11.0 (a) |
| copper | 4/12 | 3/12: 435, 15.8, 20.0 | 18.0 (a) | 12.0 (a) |
| iron | 12/12 | 5/12:146, 42.1, 18.5, 10.6, 1.21 (all in mg/L) | None listed | mg/L: 1.0 (b) |
| lead | 10/12 | 7/12: 498, 81.9, 58.0, 40.2, 4.7, 3.9, 3.4 | 82.0 (a) | 3.2 (a) |
| mercury | 2/12 | 2/12: 0.55, 0.52 | 2.4 (a) | 0.012 (a) |
| zinc | 12/12 | 4/12: 379, 370, 144, 128 | 120 (a) | 110 (a) |

EPA criteria used if Maryland criteria have not been established; average water hardness was 166 mg/L $CaCO_3$ at Old Landfill and 130.9 $CaCO_3$ at Fire Training Area; criteria based on a hardness of 100 mg/L $CaCO_3$ were used in this assessment.

Calculation of Protective Sediment Concentrations based on 1998 Ecological Risk Assessment Results

| | | Kingfisher (food chain) | | Raccoon (food chain) | |
|---|---|---|---|---|---|
| | Maximum concentration (mg/kg) | HQ based on NOAEL | Concentration at HQ of 1.0 (mg/kg) | HQ based on NOAEL | Concentration at HQ of 1.0 (mg/kg) |
| **Site 1** | | | | | |
| Acenaphthylene | 7.5 | | | 1.4 | **5.4** |
| Anthracene | 13.5 | | | 2.6 | **5.2** |
| Fluorene | 6.5 | | | 1.3 | **5.0** |
| Phenanthrene | 60 | 3.2 | **19** | 12 | **5.0** |
| Benzo(a)anthracene | 24 | 1.2 | **20** | 4.5 | **5.3** |
| Benzo(a)pyrene | 27 | 1.4 | **19** | 5.2 | **5.2** |
| Benzo(b)fluoranthene | 37 | 2.0 | **19** | 7.1 | **5.2** |
| Benzo(g,h,i)perylene | 18 | 1.0 | **18** | 3.5 | **5.1** |
| Benzo(k)fluoranthene | 17.5 | | | 3.4 | **5.1** |
| Chrysene | 27.5 | 1.5 | **18** | 5.3 | **5.2** |
| Fluoranthene | 60 | 3.2 | **19** | 12 | **5.0** |
| Indeno(1,2,3-cd)pyrene | 19 | 1.0 | **19** | 3.7 | **5.1** |
| Pyrene | 44.5 | 2.4 | **19** | 8.6 | **5.2** |
| alpha-Chlordane | 0.14 | 3.9 | **0.04** | | |
| gamma-Chlordane | 0.205 | 5.7 | **0.04** | | |
| Aluminum | 4840 | 31 | **155** | 221 | **22** |
| Cadmium | 1.56 | 2.5 | **0.6** | | |
| Chromium (total) | 24.7 | | | 36 | **0.68** |
| Copper | 26.2 | 59 | **0.44** | 6.5 | **4.0** |
| Lead | 193.5 | 343 | **0.56** | 323 | **0.6** |
| Manganese | 2800 | | | 539 | **5.2** |
| Mercury | 0.095 | 4.2 | **0.023** | 2.4 | **0.040** |
| Zinc | 93 | 3.6 | **26** | | |
| **Site 2** | | | | | |
| 4,4'-DDE | 0.24 | 1.0 | **0.2** | | |
| Aluminum | 1855 | 12 | **155** | 84 | **22** |
| Cadmium | 0.65 | 1.1 | **0.6** | | |
| Chromium (total) | 4.55 | | | 6.7 | **0.68** |
| Copper | 4.4 | 10 | **0.44** | 1.1 | **4.0** |
| Lead | 17.8 | 32 | **0.56** | 30 | **0.6** |
| Manganese | 359.5 | | | 69 | **5.2** |

NOTE: Risk-based concentration = maximum concentration/ HQ

# D

# Contaminated Media Volume Estimations

BAINBRIDGE FS
CONTAMINATED MEDIA VOLUME ESTIMATES
25-Mar-99
BY: DPA
CHK'D: uu

SITE 1: OLD LANDFILL
GROUNDWATER
(SEE FIGURE 2-1 IN THE FS)

| | | |
|---|---|---|
| AREA OF PLUME | 32 ACRES | (FROM MW DATA, SEE FIGURE) |
| DEPTH OF SATURATED OVERBURDEN | 10.4 FEET | (FROM MW GW DEPTH DATA) |
| OVERBURDEN POROSITY | 0.25 | (ASSUMED) |
| VOLUME OF PLUME IN OVERBURDEN | 83.4 ACRE-FEET | (AREA * DEPTH * POROSITY) |
| | 27.2 MILLION GALLONS | |
| DEPTH OF PLUME IN BEDROCK | 100 FEET | (FROM MW GW DEPTH & CONTAMINANT I |
| BEDROCK POROSITY | 0.05 | (FROM RI) |
| VOLUME OF PLUME IN BEDROCK | 160.0 ACRE-FEET | (AREA * DEPTH * POROSITY) |
| | 52.1 MILLION GALLONS | |
| TOTAL ESTIMATED PLUME VOLUME | 243.4 ACRE-FEET | MAJOR CONTAMINANTS: |
| | 79.3 MILLION GALLONS | Mn 10X GOAL |
| | | Fe 3X GOAL |

SITE 2: FIRE TRAINING AREA
GROUNDWATER
(SEE FIGURE 2-2 IN THE FS)

| | | |
|---|---|---|
| AREA OF PLUME | 3.6 ACRES | (FROM MW DATA, SEE FIGURE) |
| DEPTH OF SATURATED OVERBURDEN | 5.8 FEET | (FROM MW GW DEPTH DATA) |
| OVERBURDEN POROSITY | 0.25 | (ASSUMED) |
| VOLUME OF PLUME IN OVERBURDEN | 5.2 ACRE-FEET | (AREA * DEPTH * POROSITY) |
| | 1.7 MILLION GALLONS | |
| DEPTH OF PLUME IN BEDROCK | 50 FEET | (FROM MW GW DEPTH & CONTAMINANT I |
| BEDROCK POROSITY | 0.05 | (FROM RI) |
| VOLUME OF PLUME IN BEDROCK | 9.0 ACRE-FEET | (AREA * DEPTH * POROSITY) |
| | 2.9 MILLION GALLONS | |
| TOTAL ESTIMATED PLUME VOLUME | 14.2 ACRE-FEET | MAJOR CONTAMINANTS: |
| | 4.6 MILLION GALLONS | Mn 18X GOAL |
| | | Fe 13X GOAL |

SITE 1: OLD LANDFILL
SEDIMENTS
(SEE FIGURE 2-5 IN THE FS)

| | | |
|---|---|---|
| LENGTH OF DITCH | 3,100 FEET | (FROM SED DATA, SEE FIGURE) |
| WIDTH OF DITCH | 4.0 FEET | (FROM SITE OBSERVATIONS) |
| DEPTH OF CONTAMINATED SEDIMENT | 0.5 FEET | (ASSUMED) |
| VOLUME OF CONTAMINATED SEDIMENT | 6200 CUBIC FEET<br>230 CUBIC YARDS | (AREA * WIDTH *DEPTH) |

SITE 2: FIRE TRAINING AREA
SEDIMENTS
(SEE FIGURE 2-6 IN THE FS)

| | | |
|---|---|---|
| LENGTH OF DITCH | 150 FEET | (FROM SED DATA, SEE FIGURE) |
| WIDTH OF DITCH | 4.0 FEET | (FROM SITE OBSERVATIONS) |
| DEPTH OF CONTAMINATED SEDIMENT | 0.5 FEET | (ASSUMED) |
| VOLUME OF CONTAMINATED SEDIMENT | 300 CUBIC FEET<br>10 CUBIC YARDS | (AREA * WIDTH *DEPTH) |

# E

# Ecological Risk Management Recommendations

# RISK MANAGEMENT RECOMMENDATION FOR THE OLD LANDFILL AND FIRE TRAINING AREA SITES, BAINBRIDGE NAVAL TRAINING CENTER, PORT DEPOSIT, MARYLAND

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December 15, 1998

## 1.0 BACKGROUND AND OBJECTIVES

The U.S. Fish and Wildlife Service, Chesapeake Bay Field Office (CBFO) prepared a desktop ecological risk assessment (ERA) for the Old Landfill and Fire Training Area of the Bainbridge Naval Training Center (BNTC; Pinkney and Johnson 1998). The ERA was prepared according to guidance developed by the EPA Environmental Response Team (EPA 1997). This guidance requires the estimation of risks to relevant ecological receptors, which in this case included piscivorous birds and omnivorous mammals. Because no whole body fish data were available, concentrations in fish that would be consumed by these receptors were estimated on the basis of media (sediment and water) concentrations and the conservative assumption that whole body fish concentrations would be equal to sediment concentrations. The conclusions of the ERA are summarized in Section 2.0.

The objective of this document is to provide a risk management recommendation for the Old Landfill and Fire Training Area. The document is intended for review by the state and federal Remedial Project Managers with the assistance of the EPA Region III Biological Technical Assistance Group (BTAG).

## 2.0 CONCLUSIONS OF THE DESKTOP ECOLOGICAL RISK ASSESSMENT

### 2.1 Old Landfill

#### 2.1.1 Risks to Benthos

Several sediment samples had multiple chemicals at concentrations that are frequently associated with adverse biological effects. In addition, surface water concentrations in several locations exceeded state and federal ambient water quality criteria (AWQC). Thus, based on the 1991 and 1994 sampling data, it is likely that the sediment and surface water chemical concentrations pose risks to benthic organisms. However, present sediment and surface water concentrations in at least some of the sampling locations may have been reduced by the remedial actions conducted in 1994-95.

#### 2.1.2 Risks to Fish

Based on the 1991 and 1994 surface water data, there are several sample locations where 1-hour (acute) criteria were exceeded for multiple chemicals. However, the chemical data are based on unfiltered samples, which may overestimate the bioavailable fraction. In addition, it is possible that the concentrations measured in 1991 and 1994 have been reduced by the remedial actions. Nonetheless, application of conservative assumptions suggests that exposure of aquatic life, including fish, to these chemical concentrations is likely to pose risks.

### 2.1.3 Risks to Piscivorous Birds

Based on the food chain modeling, which includes considerable uncertainties, there appears to be some potential for risks to piscivorous birds. HQ values, based on the food chain screening analysis with maximum sediment and water concentrations, were less than four for nine PAHs, and approximately 4-6 for two chlordane isomers. HQ values for six metals were greater than one, ranging from 2.5 (cadmium) to 343 (lead).

### 2.1.4 Risks to Omnivorous Mammals

Based on the food chain modeling, which includes considerable uncertainties, there appears to be some potential for risks to omnivorous mammals. HQ values, based on the maximum sediment and water concentrations, were 1.3-12 for thirteen PAHs, 221 for aluminum, 36 for chromium, 6.5 for copper, 323 for lead, 539 for manganese, and 2.4 for mercury.

## 2.2 Fire Training Area

### 2.2.1 Risks to Benthos

In general, chemicals were not detected at concentrations in sediments that are frequently associated with adverse biological effects on benthos. Chemicals in several surface water samples from Happy Valley Branch slightly exceed state and federal criteria but the comparisons are highly conservative due to the use of total rather than dissolved samples. Thus, it is unlikely that surface water and sediment chemicals in Happy Valley Branch pose risks to benthos. Greater exceedances of ambient water quality occurred in swales but the samples were collected prior to the remediation of sediments.

### 2.2.2 Risks to Fish

There were few exceedances of AWQC in Happy Valley Branch. In view of the measurement of whole rather than filtered samples and the possibility that concentrations may have been reduced by the interim remedial actions, it is unlikely that fish are at risk.

### 2.2.3 Risks to Piscivorous Birds

Based on the food chain modeling, which includes considerable uncertainties, there appears to be some potential for risks to piscivorous birds. HQ values, based on the food chain screening analysis with maximum sediment and water concentrations, were 1.0 for 4,4'-DDE, 12 for aluminum, 10 for copper, and 32 for lead.

### 2.2.4 Risks to Omnivorous Mammals

Based on the food chain modeling, which includes considerable uncertainties, there appears to be some potential for risks to omnivorous mammals. HQ values, based on the maximum sediment and water concentrations, were greater than one for aluminum (84), chromium (6.7), copper (1.1), lead (30), and manganese (69).

## 3.0 RISK MANAGEMENT RECOMMENDATION FOR THE OLD LANDFILL

Based on the results of the desktop ERA, there appear to be potential risks to fish and benthos and the upper trophic level consumers of those organisms. However, there is considerable uncertainty associated with the risk assessment. The primary source of uncertainty is whether the exposure concentrations used in the ERA are reflective of existing conditions at the site. Chemical data used in this assessment were collected in 1991 and 1994, prior to remediation at both sites. While sediment samples in remediated areas were excluded from the analysis, it is possible that the remediation has also lowered chemical concentrations in down gradient areas. At the Fire Training Area, water samples from an area where sediment was remediated were used in the risk assessment because active remediation of the water did not occur. Sediments can serve as a source of contaminants to the surface water (Burgess and Scott 1992) and it is likely that the 1994-95 sediment remediation has resulted in lowered surface water concentrations. In addition, water column concentrations were based on whole rather than filtered samples and may not reflect the actual bioavailablity of contaminants to aquatic receptors. Consequently, rather than initiate remedial actions, a more appropriate course of action would be to gain a more accurate picture of existing conditions at the site through additional chemical and biological characterization.

In addition to the potential risk from chemical contaminants, another threat to the benthic community at the Old Landfill appears to be habitat degradation. Sandy soils from the landfill cover have entered the west branch stream and continued downstream after the confluence of the east and west branches. This has occurred presumably as a result of the use of an inappropriate particle size for the cover soils (F. Zepka, pers. comm.). The U.S. Navy is planning to eliminate this source of sediment loading within the next several months. As part of the remediation, the Navy should determine, with the aid of a stream restoration specialist, the likelihood that the sediment loaded into the stream will move out of the system during storms and high flow periods.

A monitoring plan to address the physical and chemical issues associated with sand and sediments in the Old Landfill streams could be attached to the Record of Decision or Decision Document. Chemical sampling would include the sediment "hotspots" identified in the earlier studies and water column samples. If necessary, sediment toxicity tests could be used to determine whether acute or chronic toxicity is associated with sediments from these presumed "hotspots". These data would be used to evaluate changes in contaminant concentrations that may have occurred since the 1994-1995 remedial action and to determine the extent of contamination, if it exists. Biological sampling would consist of the use of the EPA Rapid Bioassessment Protocol (RBP) to determine the biological and physical "health" of the Old Landfill streams. The RBP could be conducted in the near future and at a later date, either 3 or 5 years in the future. The results of the RBP would also address the physical condition of the stream and its recovery from the sand loading.

If the results of the chemical analysis indicate that only isolated areas are contaminated, one option would be to leave these small pockets in the stream. If contamination is more extensive, removal of the "hot spots" should be considered, possibly with the use of a vacuum dredge (if feasible) which is minimally destructive to habitat. If the vacuum dredge is not feasible, the benefits of sediment removal would need to be weighed against the damage caused to the riparian area by the cleanup equipment. A recommendation for cleanup and possible cleanup levels would be determined through consultation with the EPA Remedial Project Manager with the advice of the BTAG.

## 4.0 RISK MANAGEMENT RECOMMENDATION FOR THE FIRE TRAINING AREA

As stated for the Old Landfill, the calculated risks to omnivorous mammals and piscivorous birds may not be reflective of existing site conditions. There were few exceedances of AWQC or sediment guidance values. Happy Valley Branch appears to be a high quality stream that warrants protection. Thus, no active remediation of the site appears to be necessary though monitoring would be beneficial. Conduct of the RBP for fish, benthos, and habitat quality would provide valuable baseline data on the status of the stream. This study could be completed at low cost, since a similar study is recommended for the Old Landfill stream.

## 5.0 REFERENCES

Burgess, R.M. and K.J. Scott. 1992. The significance of in-place contaminated marine sediments on the water column: processes and effects. In: G.A. Burton, Jr., ed., *Sediment Toxicity Assessment*. Lewis Publishers, Boca Raton, FL, pp. 129-165.

EPA. 1997. Ecological risk assessment guidance for Superfund: process for designing and conducting ecological risk assessments. Interim final. Environmental Response Team, Edison, NJ.

Long, E.R. and L.G. Morgan. 1990. The potential for biological effects of sediment-sorbed contaminants tested in the National Status and Trends Program. NOAA Tech. Mem. NOS OMA 52, Seattle, WA.

Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations. *Environ. Manag.* 19:81-97.

Pinkney, A.E. and K.N. Johnson. 1998. Deskton Ecological Risk Assessment, Bainbridge Naval Training Center, Port Deposit, Maryland. U.S. Fish and Wildlife Service, Chesapeake Bay Field Office, Annapolis, MD. CBFO-98-04.

# F

# EPA Draft FS Comment Letter (June 18, 1999)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

June 18, 1999

Mr. Frank Zepka
Department of the Navy
Engineering Field Activity Chesapeake
Washington Navy Yard, Building 212
901 M Street SE
Washington, D.C. 20374-5018

Re: Draft Feasibility Study for Bainbridge Naval Training Center, Port Deposit, Maryland

Dear Mr. Zepka:

The Environmental Protection Agency has reviewed the above referenced document. The Feasibility Study was also reviewed for compliance with RI review comments dated 5/11/98, which included recommendations for the FS. The following comments are offered.

1. The premise for this document is that the source areas have been remediated and that any contamination left in the sediments will decrease over time. The EPA Region III BTAG is concerned that the sediments in the East and West tributaries may be acting as a secondary source of contamination. The new data collected (not analyzed yet) may help to address this concern. If this new round of data indicates that contaminants remain, the Navy should consider a risk-based monitoring plan that builds upon the ecological risk assessment developed in the Remedial Investigation Report. The risk-based monitoring plan should demonstrate that sediments in these streams are not a problem or that there is a decreasing trend in contamination proving the remedy has effectively eliminated the source. If the site risk-based monitoring indicates that sediments remain a problem, then site specific remediation goals will be developed.

2. The Navy must demonstrate that sediments carried down stream to the Susquehanna river are not acting as a secondary source to ecological receptors in the river.

3. In 1998, EPA recommended that the FS include an evaluation of blank contamination for metals, because blank-related metals were not ruled out under the former data validation. (Instead, they were qualified "J," estimated.) Section 1.5.2 includes a partial evaluation of blanks, but this is incomplete. The other risk drivers found in blanks were thallium (up to 28 $\mu$g/l) and chromium (up to 15 $\mu$g/l). Thallium was only found in blanks associated with Site 2, but the Site 2 thallium levels would have been well within the blank-affected

level (sample 2-GW-2 1 $\mu$g/l, sample 2-GW-11 1 $\mu$g/l, prep blank 1.1 $\mu$g/l). Therefore, thallium in Site 2 groundwater is questionable.

4. In 1998, EPA requested that the FS indicate whether the deed restrictions on the landfill and wetlands are pre-existing. The February 1999 comment response document indicated this would be discussed; it appears from the current FS that there are no pre-existing restrictions on these areas. Please verify.

5. In 1998, EPA requested a statistical background comparison for risk-driving metals. This was partly accommodated by the consideration of background in screening levels. However, hypothesis testing of the risk-driving metals yields the probable conclusion that they are all, with the possible exception of antimony in Site 1 groundwater, significantly greater on-site than in background wells. Site 1 antimony is difficult to evaluate, but one data set has all non-detects plus a positive hit of 42.7 $\mu$g/l, while the other is all non-detects with one hit of 32.4 $\mu$g/l.

   Section 1.5.3 uses "mean plus 2 standard deviations." This is not necessarily unacceptable for these sites, since there were 20 background samples (a fairly healthy data set), and the UTL at this level would use the mean plus 2.4 standard deviations. However, it was not clear whether the distribution type was considered. Site data were reported to be lognormal in the RI, and iron and manganese background data appear to be lognormal using the Wilk-Shapiro test. Assuming lognormality, the transformed mean + 2 standard deviations would be 1735 mg/kg for iron and 48.3 mg/kg for manganese.

6. In 1998, EPA provided a preliminary summary of risk drivers. That list is modified in today's memo, taking into consideration the Navy's response and the updating of certain toxicological criteria.

   a) Table 1-3: For Site 1 sediment and groundwater and Site 2 sediment and groundwater, beryllium was also evaluated but is no longer a COPC due to the withdrawal of the oral CSF. Aluminum and chromium in Site 1 sediment did not appear in the original numerical risk summary but were considered quantitatively by EPA. Chlordane in Site 1 sediment no longer needs to be a COPC, according to the new toxicity factors. Based on updated toxicity factors and/or RBCs, the following chemicals would now be COPCs (and were considered quantitatively by EPA during this review): mercury in Site 1 sediment; naphthalene in Site 1 groundwater; chromium in Site 2 subsurface soil; naphthalene, 1,2-dichloroethene, mercury, acenaphthene, acenaphthylene, benzo[g,h,i]perylene, dibenzofuran, and phenanthrene in Site 2 groundwater. As will be seen, the changes do not generally result in vast differences in risk estimates, although there are a few notable changes.

b) Table 1-1: The child groundwater cancer risk at Site 1 should be 2E-5 (2E-6 appears to be a misprint). For the adult groundwater user at Site 2, the specific PAH that drives cancer risk is benzo[a]pyrene (3E-4).

c) Table 1-2: For the adult groundwater user at Site 1, the chlorobenzene HQ should be 0.4; due to a new provisional RfC for chloroform, the chloroform HQ is 1.8. For recreational exposure to sediment at Site 2, the HI would be 0.02, not vastly different from the reported 0.035. For child exposure to soil at Site 2, the driving metals are chromium (HQ 1), iron (HQ 0.8), manganese (HQ 0.7), which are not additive. The chromium number is based on new, more conservative RfDs for chromium; the slightly-lower-than-previously iron value is based on no oral-to-dermal adjustment, since oral iron absorption is homeostatically controlled. For groundwater use at Site 2 by the adult, the HI should be 19, including the addition of chloroform (HQ 2.5) as a new risk driver. For child groundwater use at Site 2, thallium (HQ 0.9) should also be shown as a potential risk contributor.

d) Page 1-19, 4th paragraph: Modify the second and third sentences as follows (new material underlined): "Specifically, the groundwater at Site 1 poses a risk due to the presence of, ~~chlorinated hydrocarbons (vinyl chloride, 1,4-DCB, TCE,~~ chlorobenzene and chloroform~~), arsenic~~, iron, antimony, thallium, and manganese. However, vinyl chloride and TCE also exceeded their MCLs. At Site 2, the risk is the presence of carcinogenic PAHs (~~benzo(a)anthracene,~~ mostly benzo(a)pyrene~~, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-c,d)pyrene~~), ~~1,1,2,2-tetrachloroethane, arsenic,~~ thallium, chloroform, iron, and manganese."

e) Section 1.5.4: For child exposure to soil at Site 2, the driving metals are chromium (HQ 1), iron (HQ 0.8), and manganese (HQ 0.7), which are not additive. The chromium number is based on new, more conservative RfDs for chromium; the slightly-lower-than-previously iron value is based on no oral-to-dermal adjustment, since oral iron absorption is homeostatically controlled. (Even if the previous iron assumption were used, the iron HQ would only be approximately 1.5). Because these three metals affect different target organs, the HI is not considered to exceed 1. This is a stronger justification for no action than the "typical range," which may not apply to local soils.

f) Page 2-1, 3rd paragraph: Delete 1,4-dichlorobenzene and arsenic; add chlorobenzene, antimony, and thallium.

g) Page 2-2, 4th paragraph: Delete arsenic; add benzo[a]pyrene and thallium.

7. Section 1.4.1: Explain that risk-based screening concentrations (RBSCs) differ from the previously described "screening levels" in that RBSCs consider only risk, not background or ARARs.

8. Section 1.3.1.3, Organics: The statement that there were no PAHs in landfill groundwater should be corrected. Naphthalene and anthracene were occasionally detected, but at low levels which did not drive the risks in this area.

9. Section 1.3.2 refers to Figure 1-4 for sample locations, but Figure 1-4 contains only monitoring well locations (not soil, sediment, etc.).

10. Section 1.4.1 states that Table 1-1 summarizes COPCs. Actually, Table 1-3 summarizes COPCs while Tables 1-1 and 1-2 summarize risks.

11. Table 1-3: "1,2-Dichloroethane" should be "1,2-dichloroethene." Zinc and bis(2-ethylhexyl)phthalate were evaluated in Site 1 sediment and should be marked on this table.

12. Section 2.2.3: It is not clear why 1E-5 was used when the point of departure is 1E-6. PRGs are usually derived for 1E-6, 1E-5, and 1E-4, so that the risk managers can determine whether the point of departure levels are feasible, or whether higher risk levels are warranted. Typically, potential ARARs are used first, and if not protective (based on estimates of the risks at ARARs), then derivation of risk-based levels is applied (see the next comment).

13. Section 2.3.1.1: It is not necessary to revert to generic RBCs after the risk assessment has been done. The baseline risk assessment supersedes generic screening levels and can be used in the development of cleanup levels as follows:

Table 2-1 (substitute for FS Table 2-1):

| Chemical | pARAR ($\mu$g/l) | PRG ($\mu$g/l) | MAX ($\mu$g/l) | CHI at PRG | AHI at PRG | Target organ(s) | CR at PRG |
|---|---|---|---|---|---|---|---|
| TCE | 5 | 5 | 24 | 0.07 | 0.03 | | 2E-6 |

| Chemical | pARAR ($\mu$g/l) | PRG ($\mu$g/l) | MAX ($\mu$g/l) | CHI at PRG | AHI at PRG | Target organ(s) | CR at PRG |
|---|---|---|---|---|---|---|---|
| Vinyl chloride | 2 | 2 | 2.8 | -- | -- | -- | 6E-5 |
| Iron* | -- | 1200 | 37350 | 0.25 | 0.1 | B,L,GI | -- |
| Manganese* | -- | 300 | 6970 | 1 | 0.4 | CNS | -- |
| Chlorobenzene | 100 | 50 | 355 | 0.2 | 0.2 | L | -- |
| Antimony** | 6 | 4.5 | 32.4 | 0.7 | 0.3 | B, CVS | -- |
| Thallium** | 0.5 | 0.5 | 2.1 | 0.5 | 0.2 | L | -- |
| Chloroform | 80 | 2 | 4 | 0.01 | 0.9 | R | 3E-6 |
| TOTAL RISK | -- | -- | -- | B 1<br>L 0.9<br>CNS 1<br>R 0.01<br>CVS 0.7<br>GI 0.25 | B 0.4<br>L 0.5<br>CNS 0.4<br>R 0.9<br>CVS 0.3<br>GI 0.1 | -- | 6.5E-5 |

*Background mean + 2sd = 1700 $\mu$g/l for iron, 48 $\mu$g/l for manganese

**Chemical may be at background levels or may be blank contaminant, but data have not shown this conclusively

pARAR = Potential ARAR (lowest of MCL or non-zero MCLG)

PRG = Preliminary Remediation Goal

MAX = Maximum concentration from RI

CHI = Child Hazard Index

AHI = Adult Hazard Index

B = Blood

L = Liver

CVS = Cardiovascular

CNS = Central nervous system

GI = Gastrointestinal system

R = Respiratory

CR = Cancer Risk

Table 2-2 (substitute for FS Table 2-2):

| Chemical | pARAR (μg/l) | PRG (μg/l) | MAX (μg/l) | CHI at PRG | AHI at PRG | Target organ(s) | CR at PRG |
|---|---|---|---|---|---|---|---|
| 1,1,2,2-PCA | -- | 2 | 8 | 0.002 | 0.001 | | 1E-5 |
| Benz[a]anthracene | -- | 1 | 1 | -- | -- | -- | 1E-5 |
| Benzo[a]pyrene | 0.2 | 0.1 | 2 | -- | -- | -- | 1E-5 |
| Benzo[b]fluoranthene | -- | 1.5 | 3 | -- | -- | -- | 1E-5 |
| Benzo[k]fluoranthene | -- | 20 | 2 | -- | -- | -- | 1E-5 |
| Chrysene | -- | 200 | 2 | -- | -- | -- | 1E-5 |
| Indeno[1,2,3-c,d]pyrene | -- | 1 | 2 | -- | -- | -- | 1E-5 |
| Iron* | -- | 2300 | 79200 | 0.5 | 0.2 | B,L,GI | -- |
| Manganese* | -- | 300 | 5500 | 1 | 0.4 | CNS | -- |
| Chloroform | 80 | 2 | 16 | 0.01 | 0.9 | R | 3E-6 |
| Thallium** | 0.5 | 0.5 | 1 | 0.45 | 0.2 | L | -- |

| Chemical | pARAR ($\mu$g/l) | PRG ($\mu$g/l) | MAX ($\mu$g/l) | CHI at PRG | AHI at PRG | Target organ(s) | CR at PRG |
|---|---|---|---|---|---|---|---|
| TOTAL RISK | -- | -- | -- | B 0.5<br>L 1<br>CNS 1<br>R 0.01<br>GI 0.5 | B 0.2<br>L 0.4<br>CNS 0.4<br>R 0.4<br>GI 0.2 | -- | 7.5E-5 |

*Background mean + 2sd = 1700 $\mu$g/l for iron, 48 $\mu$g/l for manganese

**Chemical is expected to be a blank contaminant and not truly present; awaiting follow-up sampling

pARAR = Potential ARAR (lowest of MCL or non-zero MCLG)

PRG = Preliminary Remediation Goal

MAX = Maximum concentration from RI

CHI = Child Hazard Index

CNS = Central nervous system

GI = Gastrointestinal system

AHI = Adult Hazard Index

B = Blood

L = Liver

R = Respiratory

CR = Cancer Risk

The PRGs for iron and manganese are currently set at risk-based levels. However, because the background levels of these metals were very low in early rounds, it is possible that continued monitoring or an extended data search may result in updated background levels.

The PRGs are based on a combination of potential ARARs and risk-based levels. For 1E-6 cancer-based PRGs, a simple ratio derived from the "CR at PRG" and "PRG" columns can be used. For example, for chrysene at Site 2, the PRG of 200 $\mu$g/l is associated with a 1E-5 cancer risk. Therefore, the 1E-6 risk level would be found at 20 $\mu$g/l.

14. Table 2-3: For Site 1, change iron to 1200 $\mu$g/l; add chloroform (2 $\mu$g/l), chlorobenzene (50 $\mu$g/l), antimony (4.5 $\mu$g/l), thallium (0.5 $\mu$g/l). For Site 2, add 1,1,2,2-PCA (2 $\mu$g/l), chloroform (2 $\mu$g/l), and thallium (0.5 $\mu$g/l); change benz[a]anthracene to 1 $\mu$g/l, benzo[a]pyrene to 0.01 $\mu$g/l, benzo[b]fluoranthene to 1.5 $\mu$g/l, benzo[k]fluoranthene to 20 $\mu$g/l, chrysene to 200 $\mu$g/l, indeno[1,2,3-c,d]pyrene to 1 $\mu$g/l, iron to 2300 $\mu$g/l. (These recommendations assume that the above comments on PRGs are accepted.)

15. Page 2-7: The first two bullets should be switched, in accordance with the NCP. (MCLs are used when non-zero MCLGs do not exist or are not relevant and appropriate.)

16. Section 2.3.1.1 should not have used preliminary screening values, but should have used the results of the risk assessment to select risk drivers for which cleanup goals are necessary. For Site 1, add chlorobenzene, antimony, thallium (and delete 1,4-DCB and arsenic). For Site 2, add chloroform and thallium (and delete arsenic).

17. Tables 2-4, 2-5: The cadmium fish RBC is 1.4 mg/kg. The manganese fish RBC is 190 mg/kg. The mercury fish RBC is 0.14 mg/kg. It is not clear how these RBCs were used, but it should be noted that they are fish tissue values, not soil or sediment values, and as such cannot be directly compared with sediment cleanup levels.

18. Section 2.5.1.1, Section 2.5.2.1, and Figures 2-1 and 2-2 should be adjusted in accordance with previous comments on COPCs and cleanup levels.

19. Two of the figures are labeled Figure 2-2.

20. Sections 3.3.5 and 4.1.2: It is not clear how sediment institutional controls would work for ecological receptors.

21. Sections 4.1.3 and 4.2.3: Filtration, pH adjustment, chemical reduction, carbon adsorption, UV oxidation (but not at Site 2), and POTW disposal were all selected for further evaluation in Section 3, but do not appear in Section 4. Please explain.

22. Sections 5.1.1.2 and 5.2.1.2, Overall Protection and Long-Term Effectiveness: Another drawback to no action is that there would be no limits on receptor exposure or future use of the contaminated media.

23. Sections 5.1.2.1 and 6.1: See earlier comments about the list of COPCs for Site 1 (and Site 2 for Section 6.1).

24. Sections 5.1.2.2 and 5.2.2.2, Overall Protectiveness: Discuss briefly the extent of the contamination and the expectations about migration.

25. Table 5-5 (both sites) and Sections 5.1.2.2, 5.2.2.2, 5.3.1, and 5.3.2, Compliance with ARARs: Determine whether Alternative 2 requires an ARARs waiver, since ARARs will probably not be met by this alternative.

26. Table 5-5 (both sites) and Sections 5.1.2.2, 5.2.2.2, and 5.3.1, Short-term Effectiveness: The only anticipated short-term risks for Alternative 2 would be risks to workers during monitoring, which could be addressed by standard health and safety practices.

27. Table 5-5 (both sites) and Sections 5.1.3.2, 5.2.3.2, 5.3.1, and 5.3.2, Reduction of TMV: The groundwater Alternative 3 actually reduces mobility and volume more than toxicity.

28. Table 5-5 (both sites) and Sections 5.1.3.2, 5.3.1, and 5.3.2, Short-term Effectiveness: Air stripper emissions (Site 1 only) and discharge to surface water are potential sources of short-term risk.

29. Section 5.2.2.1: Please verify that 2-GW-7 is the background well; previously, 2-GW-1 was identified.

30. Section 5.2.1.2: An evaluation of overall protectiveness is needed (it appears that the header is simply missing).

31. Sections 5.1.3.2 and 5.2.3.2, Short-term Effectiveness: Discharge to surface water is a potential source of short-term risk.

32. Sections 5.3.1 and 5.3.2, Reduction of TMV: The 1994 data did include filtered samples, and they were not greatly different from the unfiltered samples.

33. Section 5.3.2, Long-term Effectiveness: The effectiveness of Alternative 2 would be based on the prevention of exposure.

34. Section 6.2: For the groundwater institutional controls, the extent of contamination and likelihood of migration should be discussed, along with a determination of whether ARARs will have to be waived. The preference for treatment should also be addressed.

35. Appendix B, Table 5-22: The inhalation CSFs for PAHs have been changed; a provisional value of 3.1 per mg/kg/day is recommended for benzo[a]pyrene by NCEA. The beryllium oral CSF has been withdrawn. The chlordane oral and inhalation CSFs have been changed to 0.35 per mg/kg/day (both). The bis(2-ethylhexyl)phthalate provisional oral CSF is 1.4E-2 per mg/kg/day. 1,4-Dichlorobenzene has an inhalation CSF of 2E-2 per mg/kg/day.

36. Appendix B, Table 5-23: The provisional inhalation RfD for aluminum is 1E-3 mg/kg/day. The new beryllium inhalation RfD is 5.7E-6 mg/kg/day, and the oral RfD is 2E-3 mg/kg/day. Cadmium also has a food RfD. The chlordane inhalation RfD is 2E-4 mg/kg/day, and the oral RfD is 5E-4 mg/kg/day. The chlorobenzene inhalation RfD is 1.7E-2 mg/kg/day. The new provisional chloroform inhalation RfD is 8.6E-5 mg/kg/day. The new chromium inhalation RfD is 3E-5 mg/kg/day; the oral RfD is 3E-3 mg/kg/day. The 1,4-DCB oral RfD is 3E-2 mg/kg/day. The 1,1,2,2,-tetrachloroethane oral RfD is 6E-2 mg/kg/day. The provisional oral RfD for TCE is 6E-3 mg/kg/day.

37. Appendix B, Table 5-24: The aluminum ABS could be 27%, although this does not significantly affect the overall risk estimates. The beryllium oral RfD and SF have changed, and therefore the dermal factors would change accordingly. The chromium RfD has changed, and the ABS could be 1%, both of which would change the dermal RfD. The iron ABS could be 100% (because homeostatic control makes it difficult if not impossible to estimate the iron oral ABS). The aldrin dermal SF should have been 17, not 1.7 (17 x 100% = 17). The chlordane RfD and SF have changed, and therefore the dermal factors would change accordingly. The 1,4-DCB, 1,1,2,2-tetrachloroethane, and TCE oral RfDs have either changed or become available, and the dermal RfDs would change accordingly. Mercury, naphthalene, phenanthrene, acenaphthene, acenaphthylene, benzo[g,h,i]perylene, dibenzofuran, and 1,2-dichloropropane could also be shown on this table, given the updated RBCs. Results of these changes were discussed above, in the overall summary of risks; except for an increase in chromium and a decrease in iron risk, these updates and corrections would not be significant.

38. Appendix B, Tables 5-25 and 5-27: FS Table 1-1 (and the above comments on that table) are a more up-to-date representation of the site risks.

If you have any questions or concerns please contact me at (215) 814-5129.

Sincerely,

Mary T. Cooke
Remedial Project Manager

cc: Bill Schmidt, MDE
Kim Lemaster, MDE